OA 2090B

White Noise Test Set

INSTRUCTION MANUAL

mi
MARCONI INSTRUMENTS

INSTRUCTION MANUAL
No. EB 2090B
for

White Noise Test Set

OA 2090B

For use with instruments having the following serial numbers:
TF 2091B Noise Generator: 161220 series and later
TF 2092B Noise Receiver: 161320 series and later

mi
Technical Publications

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Chapter 1

General information

1.1 FEATURES

White Noise Test Set OA 2090B permits the measurement of intermodulation products and noise in multi-channel telephone link equipment. A noise signal, generated by the instrument, is used to simulate full traffic conditions in any number of channels up to 2700. This signal is applied to the baseband circuit of the equipment under test and the noise in a narrow slot is compared in the loaded and unloaded states.

The instrument consists of two units: a Noise Generator type TF 2091B and a Noise Receiver type TF 2092B. The generator may be fitted with a selection of high- and low-pass filters to restrict the noise to the required bandwidth and band-stop filters to create a slot within the band. The receiver has a selection of narrow band-pass filters corresponding to the generator slots, a meter and an attenuator to measure the relative noise level as the generator slot is switched in and out.

The test set performance conforms with CCIR Recommendation 399-1 (1966) when fitted with 'B' version filters, namely filters of the series TK 2094, TK 2095 and TK 2096. The test set also accepts filters of the series TM 7720, TM 7728, TM 7729 and TM 7730, in which case the performance conforms with CCIR Recommendation 399 (1963). These earlier filters are referred to as 'A' version filters in this manual.

The generator has automatic level control to maintain constant output power when a band-stop filter is inserted and a noise on/off switch to assist measurement of residual noise. A standardizing noise source on the receiver facilitates standardization of receiver sensitivity.

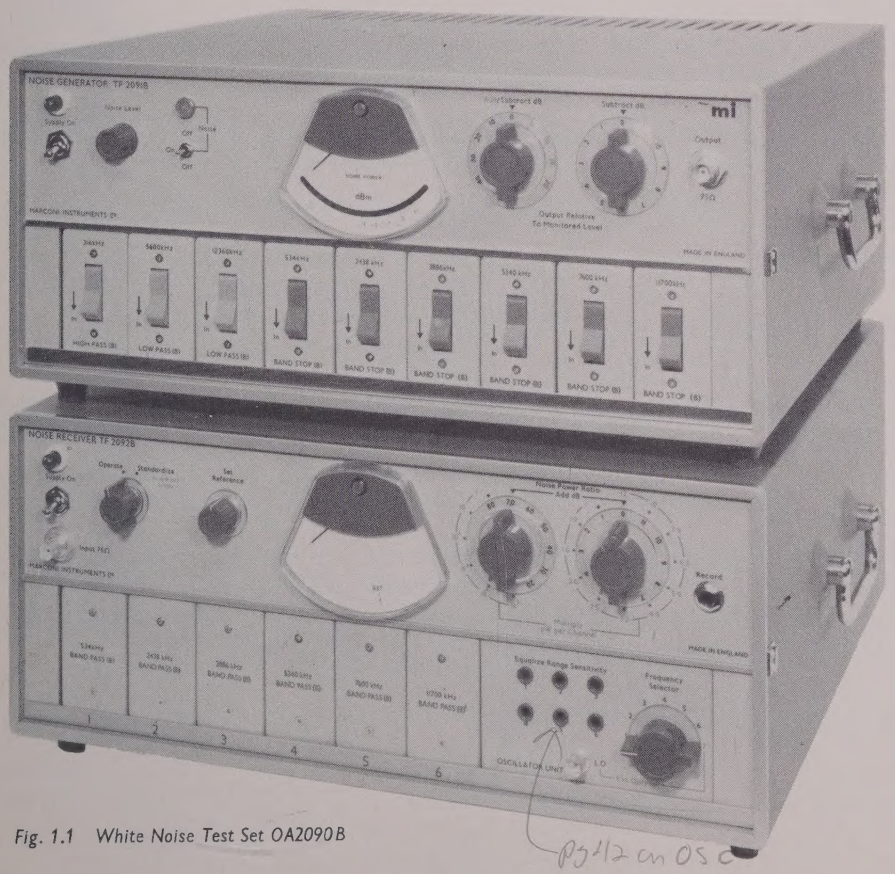


Fig. 1.1 White Noise Test Set OA2090B

1.2 DATA SUMMARY

Noise generator

The generator may be fitted with up to nine filters. These include high-pass and low-pass filters corresponding to the baseband of the system under test, and band-stop filters for selected slot frequencies - for details see 'Filter characteristics' below and for type numbers see Appendix I.

Noise band :

White noise is generated over the frequency band from below 12 kHz to above 12360 kHz. Within the bandwidth corresponding to the baseband of the system under test, the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz does not vary by more than ±0.5 dB.

The noise band is limited by the high-pass and low-pass filters selected.

Output :

Noise power density is adjustable to at least -14.5 dBm/kHz with 'B' version filters or -12.5 dBm/kHz with 'A' version filters.

Maximum total power is +20 dBm.

Noise output may be switched off at the front panel.

Peak factor :

Greater than 12 dB up to +17 dBm output level.

A.L.C. :

Maintains the output power constant when switching band-stop filters, and also when switching band-limiting filters, provided the noise power density is within the specified limit.

With a meter indication between -1 dB and +1 dB the power level is restored to within 0 and -0.25 dB of the original level after inserting a band-stop filter.

Attenuators : Coarse :

Above 0 dBm in four steps of 5 dB to +20 dB.
Below 0 dBm in four steps of 10 dB to -40 dB.

Fine :

0 to -11 dB in eleven steps of 1 dB.

Meter calibration :

0 to ±1 dBm in 0.2 dB increments,
0 to -3 dBm in 1 dB increments.
Accuracy: ±0.1 dB at ±1 dBm,
±0.3 dB at -3 dBm.

Output level accuracy :

±0.3 dB at 0 dBm (meter indication 0 dBm and 0 dB attenuator setting).

Additional error at other levels is ±0.5% of fine attenuator dB setting, ±0.5% of coarse attenuator dB setting, ±0.1 dB.

Output impedance :

75 Ω. Return loss greater than 20 dB when the attenuators are set for 0 dBm and below.

Power requirements :

95 V to 130 V or 190 V to 260 V a.c.;
45 Hz to 500 Hz; 50 VA.

Dimensions and weight :

Height	*Width*	*Depth*
195 mm (7 3/4 in)	475 mm (18 3/4 in)	432 mm (17 in)

Weight without filters : 12.0 kg (26½ lb).

Weight of typical filter : 0.6 kg (1¼ lb).

Noise receiver

The receiver may be fitted with up to six band-pass filters and six local oscillator boards - for details see 'Filter characteristics' below and for type numbers see Appendix I.

Number of channels : Up to six. Switch selected.

Effective bandwidth : Nominally 2.2 kHz.

Sensitivity : With 'B' version filters: Better than -130 dBm/kHz.

With 'A' version filters: Better than -120 dBm/kHz. The gain of each reception band is adjustable to give equal sensitivity for the six bands.

Inherent noise : Inherent noise density is equivalent to the sensitivity figure.

Input attenuator : Direct reading in noise power ratio and in pW of noise power per 3.1 kHz bandwidth.

Range : 0 to 91 dB in eight steps of 10 dB and eleven steps of 1 dB.

Accuracy : ±0.5% of attenuation value ±0.1 dB.

Calibration : 0 to 91 dB in terms of noise power ratio. 1 pW to 13 x 10^5 pW in terms of noise power per 3.1 kHz bandwidth.

Input impedance : 75 Ω. Return loss greater than 20 dB for all positions of input attenuator when the indicated level exceeds 0.1 pW.

Recorder output : Suitable for use with 1 mA recorders.

Standardizing noise source :

Level : 1 pW (-90 dBm) per 3.1 kHz bandwidth (-95 dBm per kHz bandwidth).

Characteristic : Noise is generated over the band 10 kHz to 13 MHz, within which band the level does not vary by more than ±0.25 dB.

Accuracy : ±0.5 dB at 1 pW per 3.1 kHz bandwidth.

Local oscillator : Up to six local oscillator boards may be fitted.

Local oscillator output : Between 0.3 V and 0.7 V e.m.f. depending on frequency.

Source impedance typically 1.5 kΩ in parallel with 75 pF.

External local oscillator input : 0.6 V ±20%. Input impedance typically 6 kΩ in parallel with 60 pF.

Power requirements : 95 V to 130 V or 190 V to 260 V a.c.; 45 Hz to 500 Hz; 15 VA.

Dimensions and weight :

Height	Width	Depth
195 mm (7 3/4 in)	475 mm (18 3/4 in)	432 mm (17 in)

Weight without filters or local oscillators : 12.3 kg (27 lb).

Weight of typical filter : 0.6 kg (1¼ lb).

Overall equipment

Inherent intermodulation and noise : Measured as a back-to-back noise power ratio, i.e. with the generator output connected directly to the receiver input and with the power level not greater than that recommended by CCIR as the loading for the bandwidth in use when measured at a zero transmission level point (dBm = dBm0),

With 'B' version filters: better than 67 dB.

With 'A' version filters: better than 75 dB above 50 kHz and better than 70 dB at 50 kHz and below.

Filter characteristics—'B' version

Band-stop and band-limiting filters of the TK 2094, TK 2095 and TK 2096 series meet CCIR Recommendation 399-1 (Oslo 1966) or CCITT Question 8/C Annex 1, Mar del Plata 1968 at the frequencies specified in these two documents. At other frequencies the characteristics are derived by interpolation from CCIR Recommendation 399-1 and are specified in document ICSC/T-40-21E (Revision 1) from COMSAT.

Band-limiting filters (TK 2095 and TK 2096 series)

Cut-off frequency* :

	Nominal freq. kHz	Tolerance kHz	Nominal freq. kHz	Tolerance kHz
High-pass (f_1)	12	±0.5		
	60	±1		
	316	±5		
Low-pass (f_2)	108	±1	1 796	±12
	252	±2	2 600	±20
	300	±2	3 284	±25
	408	±3	4 100	±30
	552	±4	5 600	±50
	804	±6	8 160	±75
	1 052	±8	12 360	±100
	1 296	±8		

Insertion loss :

Within pass band : Variation less than 0.2 dB in a band which includes the outer measuring channel.

Outside pass band :

Frequency	Loss greater than
0.8f1	25 dB
1.1f2	20 dB
1.2f2	25 dB

**Defined as the cut-off frequency of a hypothetical filter with square cut-off characteristics transmitting the same power as the practical filter*

Band-stop filters (part of TK 2094 series)

Characteristic :

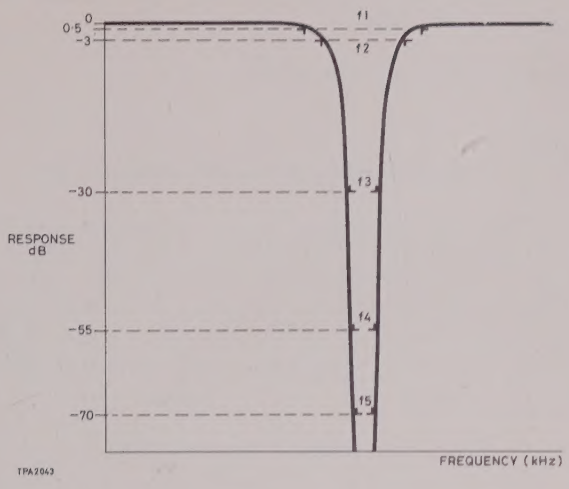


Fig. 1.2 Band-stop characteristic (TK 2094 series)

Centre frequency in kHz (fc)	Bandwidth, in kHz relative to fc, over which the discrimination is at least:			Bandwidth, in kHz relative to fc, outside of which the discrimination does not exceed:	
	70 dB (f5)	55 dB (f4)	30 dB (f3)	3 dB (f2)	0.5 dB (f1)
16	±1.5	±2.1	±2.7	±5	±7
40	±1.5	±1.8	±2.1	±4	-
56	±1.5	±1.8	±2.1	±4	-
70	±1.5	±2.2	±3.5	±12	±18
98	±1.5	±1.8	±2.1	±4	±9
140	±1.5	±1.8	±2.2	±5	±14
185	±1.5	±1.8	±2.2	±5	-
240	±1.5	±1.8	±2.2	±5	±21
270	±1.5	±2.3	±2.9	±8	±24
394	±1.5	±3.0	±4.5	±11	±35
534	±1.5	±3.5	±7.0	±15	±48
770	±1.5	±3.8	±8.0	±21	±70
1 002	±1.5	±4.0	±9.0	±27	±90
1 248	±1.5	±4.0	±11.0	±35	±110
1 730	±1.5	±4.2	±14.0	±48	±155
2 438	±1.5	±4.5	±19.0	±60	±220
3 150	±1.5	±9.0	±22.0	±85	±285
3 886	±1.5	±1.8	±3.5	±12	±100
4 650	±1.5	±2.0	±3.8	±13	±120
5 340	±1.5	±2.2	±4.0	±14	±140
7 600	±1.5	±2.4	±4.6	±16	±200
11 700	±1.5	±3.0	±7.0	±20	±300

Band-pass filters (part of TK 2094 series)

Characteristic : Designed to suit the corresponding band-stop filter.

Filter characteristics—'A' version

Band-limiting and band-stop filters of the TM 7720, TM 7728 and TM 7729 series meet CCIR Recommendation 399, (Los Angeles 1963).

Band-limiting filters (TM 7720 and TM 7728 series)

Characteristic :

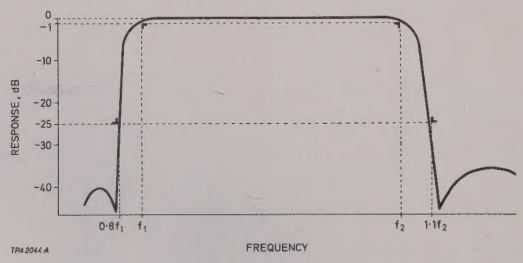


Fig. 1.3 Band limited noise

Insertion loss :

Within pass band : Variation less than 1 dB.

Outside pass band :

Frequency	Loss greater than
0.8 f1	25 dB
1.1 f2	25 dB

Band-stop filters (TM 7729 series)

Characteristic :

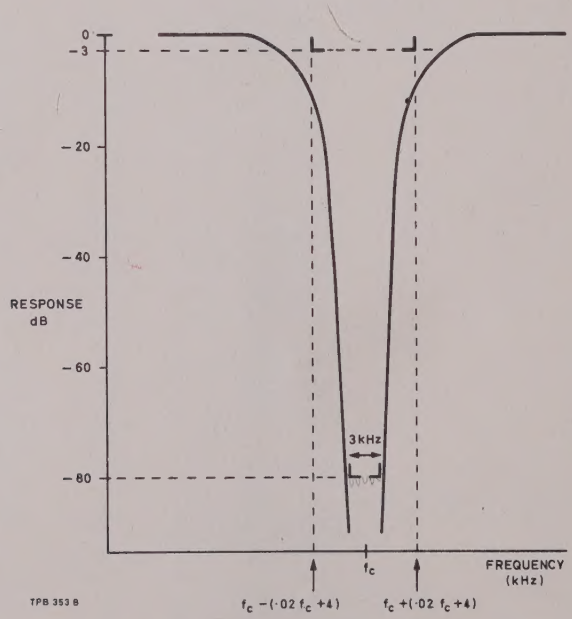


Fig. 1.4 Band-stop characteristic (TM 7729 series)

Attenuation is greater than 80 dB over a bandwidth of at least 3 kHz and greater than 3 dB at frequencies of (0.02 fc + 4) kHz from the centre frequency, fc.

Band-pass filters (TM 7730 series)

Characteristic : Designed to suit the corresponding band-stop filter.

Filter characteristics—out-of-band types

Out-of-band filter sets TK 2084 series consist of a band-stop filter, a band-pass filter and a local oscillator. The filter sets meet CCIR Recommendation 398-2, i.e. the attenuation of the band-stop filters exceeds 50 dB over a minimum frequency band of ±(0.005f + 2) kHz* (f being the centre frequency in kHz of the measuring channel). The additional attenuation, caused by the insertion of the band-stop filters at the lower and at the upper edges of the total multiplex signal band, does not exceed 0.3 dB referred to the additional attenuation caused in the centre of the multiplex signal band.

1.3 ACCESSORIES

Accessories supplied

Two BNC plugs, Greenpar type GE 37570C 30.
One telephone plug, Bulgin type P38.
For bench mounting OA 2090B: two Mains Leads type 43123-076.
Or, for rack mounting OA 2090BR: two free sockets, Bulgin type P430/SE.

Accessories available

Selective filter sets comprising band-stop filters, band-pass filters and local oscillator boards.
Band-limiting filters : high-pass and low-pass.

} See Appendix I at rear of manual

Noise Filter Extension Unit type TK 2099 ser. : a receptacle in which can be mounted an additional complement of filters and local oscillator boards so that the module capacity of an OA 2090B is doubled. Includes leads for connection to the OA 2090B after modification to the latter.

Matching Transformer 54481-011: 75 Ω unbal. to 150 Ω bal. (was TM 5955).
Matching Transformer 54481-021: 75 Ω unbal. to 140 Ω bal. (was TM 5955/1).
Connecting Lead 54351-011: 6 ft long with BNC plug at each end (was TM 4726/260).
Front-panel Cover 54124-021 (was TM 7958/3).
Front-panel Cover 54124-011, provides stowage for leads (was TM 7510).
Front Plate (Dummy) 54134-011 (was TM 7957).
Rack Mounting Kit, TM 8270, to fit one unit into a 19 in rack.

*Except when the centre frequency is 10 kHz; the minimum frequency band is then 10 ±1 kHz.

Chapter 2

Operation

2.1 PRINCIPLES OF OPERATION

Frequency division multiplex cable and radio relay systems may carry as many as 2700 different telephone channels with a 4 kHz spacing in a total bandwidth of approximately 12.5 MHz.

In such systems it is essential that intermodulation and thermal interference in any channel, due to the telephone traffic in other channels, is kept to a minimum. The former is produced mainly by non-linearity and phase distortion and is audible to a subscriber as interference resembling random noise.

If white noise (that is random noise of uniform frequency distribution) occupying the traffic bandwidth is applied to the system at a suitable power level, a fully loaded telephone system will be very closely simulated. Furthermore, if a filter with a very narrow stop band is interposed between the white noise source and the system, the conditions then existing will be equivalent to a fully loaded system except for one quiet channel. A receiver tuned to the quiet channel may be used to indicate the noise level produced by intermodulation of the components of the white noise occupying the remainder of the frequency band. The method outlined is similar to, say, a 600 channel system in which 599 channels are in use by subscribers and the remaining channel is used to listen to the noise produced by the 599 telephone conversations.

Measurements are normally made at three widely separated channel frequencies. The highest frequency is more sensitive to phase distortion and intermodulation in the r.f. and i.f. circuits under test. Undesired mixer frequency components (crossover distortion) are most noticeable at the middle frequency and non-linearity at the lowest frequency. The effects become more marked as the number of channels increase because the channel frequencies being measured become more separated.

To make a measurement, white noise of the appropriate bandwidth and power level is applied from the noise generator - with all slot filters 'out' - to the system under test. The output of the system is connected to the noise receiver, which is switch tuned to the frequency of the band-stop filter it is desired to employ for producing

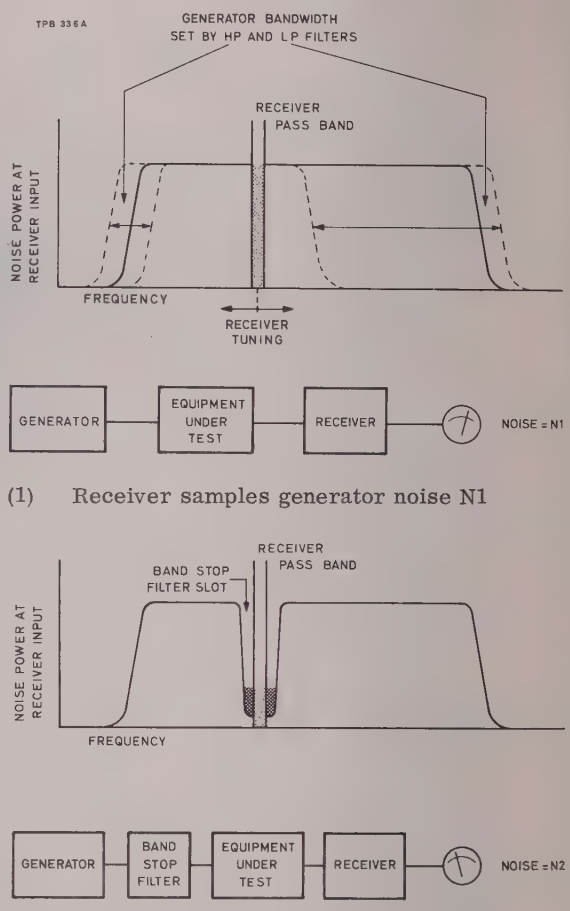


Fig. 2.1 Principle of operation

the quiet channel. Receiver sensitivity should be adjusted to give a convenient meter reading when the receiver input attenuator is set to approximately maximum attenuation. The band-stop filter is switched in and attenuates the noise in a narrow portion of the generator band, see filter characteristics in the Data Summary.

To measure the noise level in this narrow slot at the receiving end of the system, the noise receiver input attenuator must be adjusted to restore the original meter deflection. The difference between the initial and final attenuator

settings in decibels, referred to as the noise power ratio, gives a measure of the amount of intermodulation and thermal noise produced in the system.

2.2 PREPARATION FOR USE

Installation

TF 2091B and TF 2092B are electrically independent and need not be mounted close together. It is possible to arrange them at opposite ends of a radio link, assuming the operators can communicate with each other.

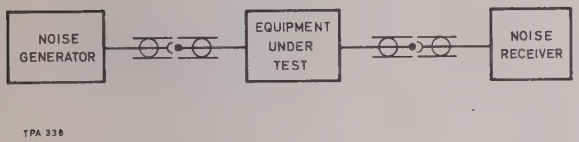


Fig. 2.2 Connections to equipment

TF 2091BR and TF 2092BR are rack-mounting versions to fit a standard 19 in rack.

In common with other apparatus employing semiconductor devices, the performance of the instruments may be affected if they are subjected to excessive temperatures. Therefore, completely remove the plastic covers if supplied, and avoid using the instruments over, or near to, hot equipment. Keep them well away from transmitter r.f. output fields.

Power supply

Normally the test set is supplied with the mains selector switch on each instrument set for supply voltages within the range 190 to 260 V. For input voltages in the range 95 to 130 V the selector switch on the rear panel must be moved to the 115 V setting from the previous 230 V setting. Do this by unscrewing the plate securing the switch button, pressing the switch to the required position, reversing the plate and replacing it to hold the switch in the new position. Change the mains fuses from 100 mA to 250 mA in the noise receiver, and from $\frac{1}{2}$ to 1 A in the noise generator for use on the lower voltage range.

Attach a suitable 3 pin plug to the mains lead, noting that the wires will be colour coded according to one of the following schemes:

Connection	Colour	Sleeve
Line (phase)	Brown	
Neutral	Blue	Black with white 'N'.
Earth (ground)	Yellow/ Green	Yellow with green earth symbol.

Mechanical meter zero

If necessary adjust the meter zero, with the supply switched off, by small adjustments to the screw above the meter window.

Combinations of 'A' and 'B' version filters

Before connecting to the equipment under test, check that the correct filters and local oscillators are fitted. (Fitting instructions are given in chapter 4.)

The test set will accept either 'A' version or 'B' version filters as listed in Appendix I. The two versions are mechanically compatible and are subject to the same operating procedure. Electrically the 'B' version has a better performance, as detailed in Sect. 1.2, which enables a higher n.p.r. measurement accuracy to be obtained. Because of this difference it is safest to use either all 'B' version or all 'A' version at a given frequency. However, it is permissible to use 'A' version band-stop filters in a generator with 'B' version band-pass filters and local oscillators in the receiver.

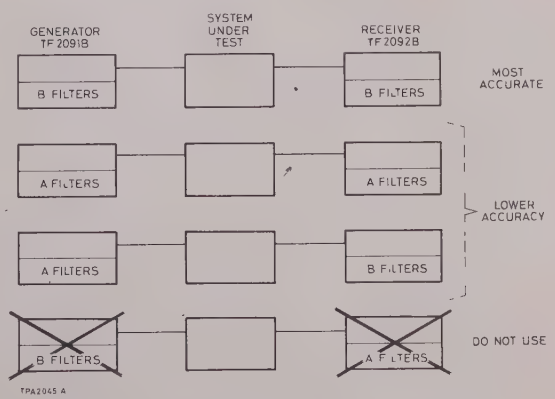


Fig. 2.3 Permissible combinations of versions of filters

This combination works because the wider slot of the 'A' version band-stop filter allows the instrument n.p.r. to be maintained. The converse arrangement must not be used, that is 'B' version band-stop filters with 'A' version band-pass filters and local oscillators - see Fig. 2.3. The 'B' filters can be distinguished by the (B) on their front panels.

Selection of filters

To meet CCIR Recommendation 399-1 (1966), select 'B' version filters as in Table 2.1. The high-pass and low-pass filter frequencies are given in columns 3 and 4 and the band-stop frequencies by column 5.

Table 2.1

System capacities and 'B' version filter frequencies (CCIR Recommendation 399-1)

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Effective cut-off frequencies of band limiting filters (kHz) High-pass	Low-pass	Centre frequencies of in-band measuring channels (kHz)						
60	60-300	60	300	70	270					
120	60-552	60	552	70	270	534				
300	60-1300 64-1296	60	1296	70	270	534	1248			
600	60-2540 64-2660	60	2600	70	270	534	1248	2438		
960	60-4028 64-4024	60	4100	70	270	534	1248	2438	3886	
900	316-4188	316	4100			534	1248	2438	3886	
1260	60-5636 60-5564	60	5600	70	270	534	1248	2438	3886	5340
1200	316-5564	316	5600			534	1248	2438	3886	5340
1800	312-8120 312-8204 316-8204	316	8160			534 7600	1248	2438	3886	5340
2700	312-12336 316-12388 312-12388	316	12360			534 7600	1248 11700	2438	3886	5340

Table 2.2

'B' version filter frequencies for INTELSAT IV (COMSAT ICSC/T-40-21E) and CCITT

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Effective cut-off frequencies of band limiting filters (kHz) High-pass	Low-pass	Centre frequencies of in-band measuring channels (kHz)				
*24	12-108	12	108	16	98			
36	12-156	12	156	16	140			
*60	12-252	12	252	16	240			
72	12-300	12	300	16	270			
96	12-408	12	408	16	240	394		
*132	12-552	12	552	16	240	534		
192	12-804	12	804	16	394	770		
252	12-1052	12	1052	16	534	1002		
312	12-1300	12	1296	16	534	1248		
432	12-1796	12	1796	16	534	1002	1730	
612	12-2540	12	2600	16	770	1730	2438	
792	12-3284	12	3284	16	1002	2438	3150	
972	12-4028	12	4100	16	1002	2438	3886	
1092	12-4892	12	4892	70	1002	2438	4650	
1872	12-8120	12	8160	70	1002	3150	5340	7600

*These also apply to ANNEX 1/Question 8c CCITT (Mar del Plata 1968).

To meet specifications by CCITT (Mar del Plata 1968) and COMSAT ICSC/T-40-21E (w/4/71), select 'B' filters as in Table 2.2.

To meet CCIR Recommendation 399 (1963), 'A' version filters can be used as in Table 2.3. The high-pass and low-pass filter frequencies are the same as given by the limits of the band occupied.

All three tables (2.1 to 2.3) apply to in-band testing. Out-of-band testing is dealt with later in this chapter. Type numbers of plug-in units are given in Appendix I.

Note that the measuring frequency of certain 'B' filters may be within a base bandwidth, but may be unsuitable for use in that baseband. These (plus those outside the baseband) are indicated in Appendix II by the absence of a correction factor.

Connecting to the equipment under test

The test set is designed for use with equipment of 75 Ω impedance and is fitted with BNC sockets. It is essential that 75 Ω cable be used.

Connect the generator OUTPUT socket to the input of the equipment under test and the output of the equipment to the INPUT socket of the receiver. When making a test on a link system the generator may have to be remote from the receiver, when the test procedure requires two operators with inter-communications. Alternatively, the 'go' and 'return' circuits can be looped so that the generator and receiver are on the same site (see Fig. 2.4) to indicate go/no go. Further testing would be necessary to determine the faulty link.

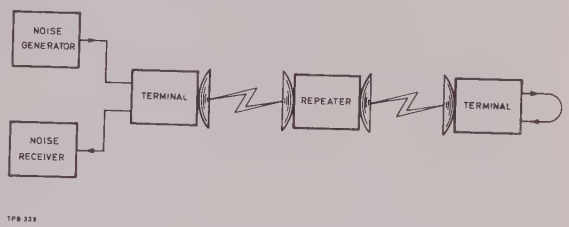


Fig. 2.4 Loop testing of radio link

The apparatus may be used immediately upon switching on, but maximum stability is not reached for several minutes.

Table 2.3

System capacities and 'A' version filter frequencies (CCIR Recommendation 399)

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Centre frequencies of in-band measuring channels (kHz)		
12	12-60	27	40	56
24	12-108	40	70	105
36	12-156	40	70	105
48	12-204	40	105	185
60	12-252	40	185	245
*60	60-300	70	185	270
*120	60-552	70	270	534
240	60-1052	70	534	1002
*300	60-1300	70	534	1248
*600	60-2660	70	1248	2438
*960	60-4028	70	2438	3886
*960	316-4188	534	2438	3886
1200	316-5564	534	3886	5340
*1800	316-8204	534	3886	8002
*2700	316-12388	534	3886	12150

* Meet CCIR Recommendation 399

2.3 CONTROLS

Generator

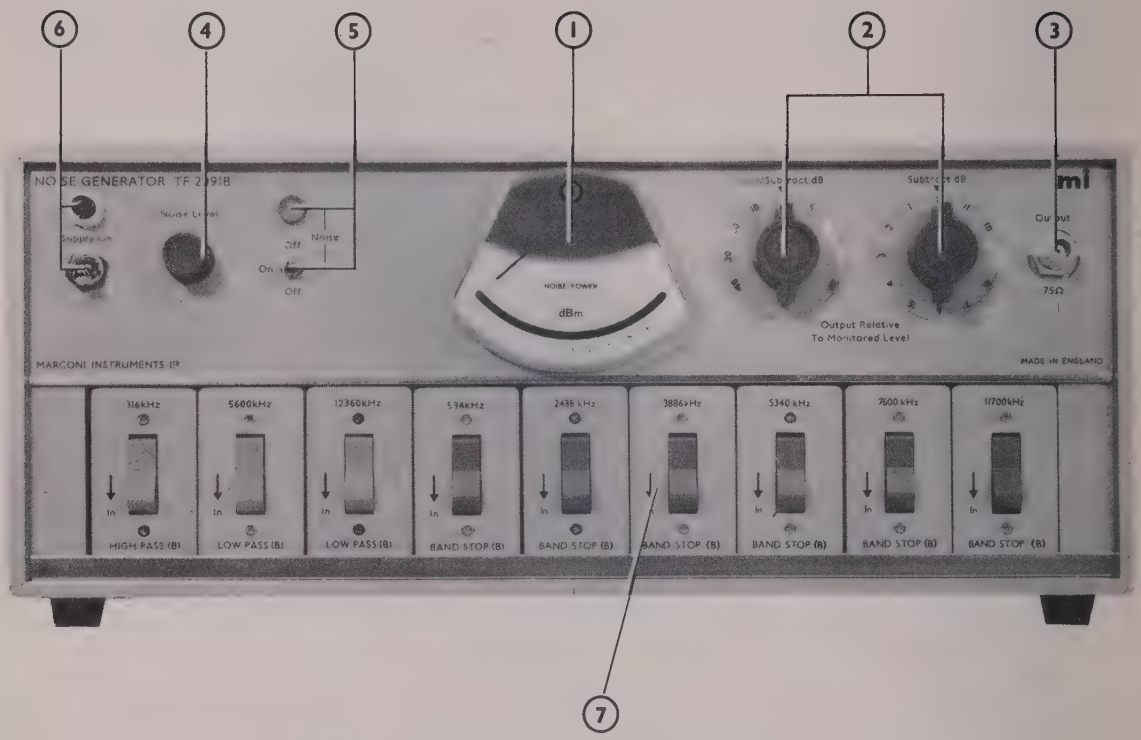


Fig. 2.5a Generator controls

① METER. Indicates available power in decibels relative to 1 mW in a 75 Ω load at the OUTPUT socket. Actual power output is given by the meter reading plus the algebraic sum of the attenuator dial settings.

② OUTPUT ATTENUATOR controls. Adjust output in 10 dB, 5 dB and 1 dB steps. Positions marked in red indicate settings to be added to the meter reading, positions marked in black indicate settings to be subtracted.

③ OUTPUT socket. BNC type, 75 Ω.

④ NOISE LEVEL control. Controls the noise power monitored on the meter by varying the gain of the high level amplifier.

⑤ NOISE ON/OFF switch and warning lamp. Switches off the noise output. The lamp lights up if the noise is switched off.

⑥ SUPPLY switch and pilot lamp.

⑦ FILTERS. High-pass and low-pass determine the noise bandwidth; band-stop create slots in the noise band.

Receiver

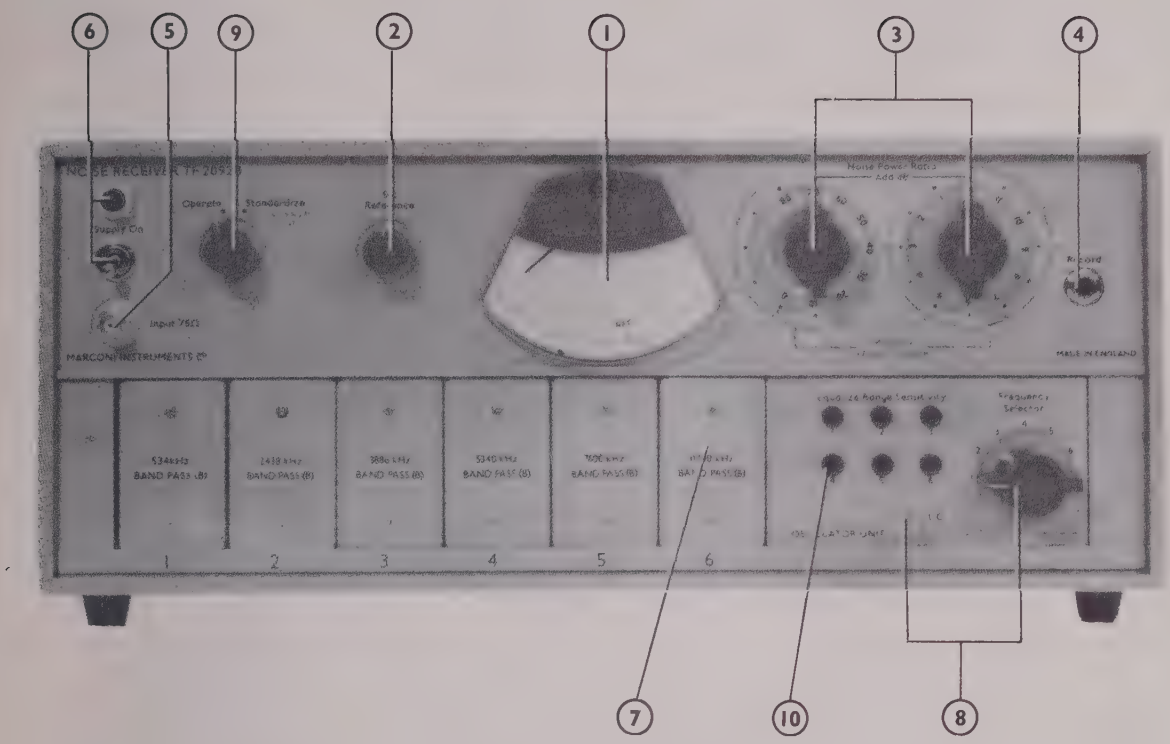


Fig. 2.5b Receiver controls

① METER. Indicates the reference level for noise power ratio measurement. Graduations around the 'REF' mark, which are in approximate steps of 0.2 dB, assist interpolation between the 1 dB steps of the fine attenuator. For the most accurate measurements the attenuator must always be used to set the meter pointer as near to the 'REF' mark as possible.

② SET REFERENCE control. Adjusts receiver gain to give a standard meter reading.

③ N.P.R./NOISE INPUT controls. Adjusts the receiver input in 10 dB and 1 dB steps. Calibrated in pW per channel and noise power ratio. To facilitate direct reading, the coarse attenuator skirt is adjustable independent of the attenuation setting.

④ RECORD jack. Accepts 2-pole telephone jack for connection to external indicator or recorder.

⑤ INPUT socket. BNC type, 75 Ω.

⑥ SUPPLY switch and pilot lamp.

⑦ FILTERS. Determine receiver pass band centre frequency, which must coincide with generator band-stop filter frequency.

⑧ FREQUENCY SELECTOR switch. Positions 1-6 select the band-pass filter and the appropriate oscillator, providing the local oscillator frequency at the L.O. socket. Position 7 allows an external signal to be connected at the L.O. socket.

⑨ OPERATE/STANDARDIZE switch. Selects input or standardizing noise source signal to feed into input attenuators. In the STANDARDIZING position the INPUT socket is terminated in 75 Ω.

⑩ EQUALIZE RANGE SENSITIVITY controls. Allows each channel to be set to the same sensitivity.

2.4 SETTING UP THE NOISE GENERATOR

The output of the noise generator must be terminated in 75 Ω when the instrument is being set up. Normally the equipment under test will provide the termination.

1) Switch in a high-pass and a low-pass filter to give the noise bandwidth required by the equipment under test as shown in Tables 2.1 to 2.3. Do not use more than one high-pass and one low-pass filter at a time. Switch out all the band-stop filters.

2) Set the required loading level using the OUTPUT ATTENUATORS in conjunction with the NOISE LEVEL control. The loading level at baseband interconnection point is given in Table 2.4, column 4. (For a back-to-back test, i.e. generator connected directly to receiver, use column 3.) Fractions of 1 dB can be set on the meter using the NOISE LEVEL control, maximum accuracy being achieved when the meter indicates within the ±1 dB region. For levels greater than 0 dBm optimum accuracy is obtained with minimum attenuation in the fine attenuator.

Example 1. To set -23.2 dBm.

Set the coarse attenuator to indicate 20 dB (shown in black on the knob skirting) and the fine attenuator to indicate 3 dB. Using the NOISE LEVEL control set the meter to indicate -0.2 dBm.

Example 2. To set +19.3 dBm (back-to-back test).

Set the coarse attenuator to indicate 20 dB (shown in red on the knob skirting) and the fine attenuator to indicate 0 dB. Using the NOISE LEVEL control set the meter to indicate -0.7 dBm.

If a non-standard bandwidth is used adjust for a meter reading corresponding to the level derived from the formulae below. These represent the correct power for applying to a point of zero relative level in the system.

$(-15 + 10 \log_{10} N)$ dBm for 240 channels or above,

$(-1 + 4 \log_{10} N)$ dBm for 12 to 240 channels,

where N equals the number of channels.

Table 2.4

Levels according to CCIR recommendation 399-1 (1966)

Number of telephone channels	*Relative power level at baseband interconnection point (dBr)*	*Level of the conventional load (dBm0)*	*Nominal power level of the test signal at the baseband interconnection point (dBm)*
*12	-36	3.3	-32.7
24	-36	4.5	-31.5
*36	-36	5.2	-30.8
*48	-36	5.7	-30.3
60	-36	6.1	-29.9
120	-36	7.3	-28.7
132	-36	7.5	-28.5
*240	-36	8.8	-27.2
300	-36	9.8	-26.2
600	-36	12.8	-23.2
600	-33	12.8	-20.2
960	-36	14.8	-21.2
960	-33	14.8	-18.2
1260	-33	16.0	-17.0
1800	-33	17.5	-15.5
2700	-33	19.3	-13.7

* Level and frequencies of band limiting filters recommended prior to 1966

2.5 SETTING UP THE NOISE RECEIVER FOR MEASURING NOISE POWER RATIO

When the generator has been set as in Sect. 2.4 and the receiver has been fitted with the appropriate band-pass filters and oscillators, (for selection see Tables 2.1 to 2.3 and for method of fixing Sect. 4.5 and 4.6), connect the equipment as in Fig. 2.6a. The receiver is set up to measure noise power ratio (n.p.r.) as follows:

(1) Turn all EQUALIZE RANGE controls fully clockwise using a screwdriver.

(2) Turn the SET REFERENCE control to mid-travel.

(3) Choose one of the selected measurement frequencies by means of the FREQUENCY SELECTOR switch.

(4) Switch the OPERATE/STANDARDIZE switch to OPERATE.

(5) Switch the fine N.P.R./NOISE INPUT control to indicate 0 dB, that is with the symbol 0 on the skirt vertical and coincident with the black arrow.

(6) Adjust the coarse N.P.R./NOISE INPUT control until the meter reading is close to the REF mark.

NOTE: Step (7) and step (9) can be omitted if comparative measurements between channels are not required.

(7) Switch the FREQUENCY SELECTOR to the other selected frequencies in turn and note which gives the minimum meter reading. Leave the switch at the position of minimum reading.

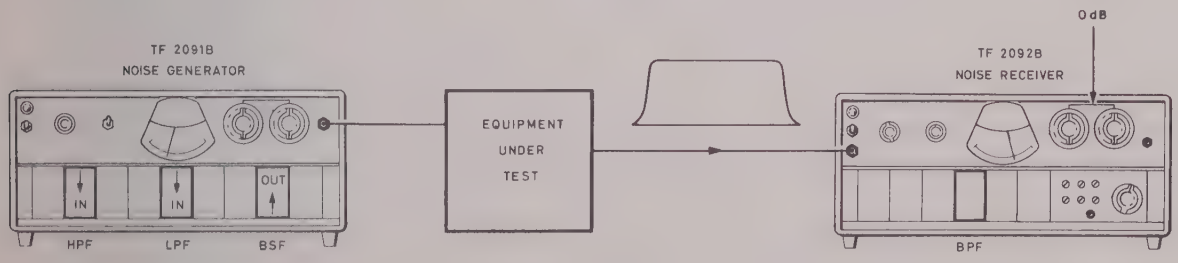
(8) Adjust the SET REFERENCE control to give a meter reading on the reference mark.

(9) Switch the FREQUENCY SELECTOR to the other frequencies and, without touching the SET REFERENCE control, adjust the EQUALIZE RANGE SENSITIVITY presets to give a meter reading at the same reference mark. (Use only the EQUALIZE RANGE SENSITIVITY control for the particular range, e.g., adjust EQUALIZE RANGE SENSITIVITY control 4 when FREQUENCY SELECTOR is switched to range 4.)

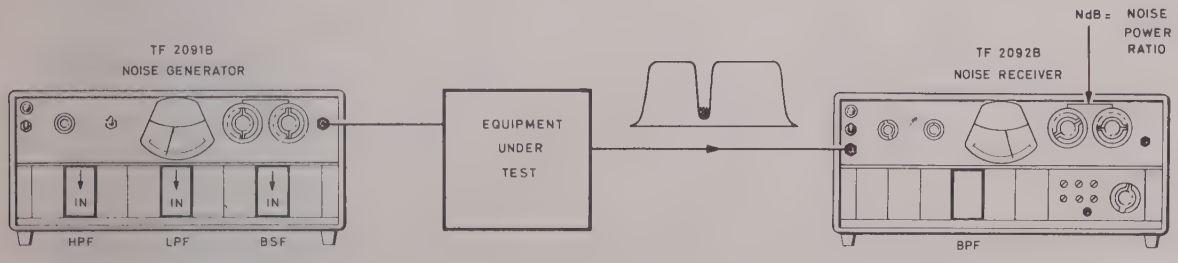
NOTE: With certain combinations of 'A' and 'B' band-pass filters in the same receiver, gain equalization may not be possible.

(10) Leaving the control knob in the same switch position, adjust the calibrated skirt of the coarse N.P.R. control so that the symbol 0 is vertical, i.e. coincident with the black indicating arrow. (The skirt is turned by pushing it towards the front panel and rotating it, when clicks corresponding to each position will be felt.)

With the coarse and fine controls set in this position it will be noted that the indicated n.p.r. is 0 dB. The receiver is now set up to measure noise power ratio



a) Band-stop filter out



b) Band-stop filter in

Fig. 2.6 Measuring noise power ratio

2.6 MEASUREMENT OF NOISE POWER RATIO

The noise power ratio (n.p.r.) of an equipment or link, measured in the way detailed below, is the ratio of (i) the portion of the noise representing a multi-channel signal that occurs in a narrow bandwidth; to (ii) the inherent and intermodulation noise in the same bandwidth when signals are not applied in that band but are applied over the remainder of the multi-channel frequency range. Part (i) of the ratio also includes inherent and intermodulation noise, but this is negligible in comparison with the noise representing the signal.

Having set up the noise generator and noise receiver, as described in Sect. 2.4 and 2.5, the n.p.r. can be measured at any of the band-stop filter frequencies. Proceed as follows:-

(1) Turn the FREQUENCY SELECTOR switch to the frequency at which the measurement is to be made. The switch positions are numbered and the first six of these correspond to the band-pass filters fitted.

(2) Switch IN the generator band-stop filter of the same frequency as that selected in (1), see Fig. 2.6. The generator meter reading should remain the same since a.l.c. is applied. (Only if second order non-linear distortion dominates, should a correction be applied; this is described later.)

(3) Adjust the receiver coarse and fine N.P.R./NOISE INPUT controls (set to 0 dB in Sect. 2.5) so that the receiver meter indication is restored to the reference mark. The n.p.r. is obtained by adding the dB readings, i.e. the sum of the figures indicated by the black arrows against the two attenuator skirts.

NOTE: As the n.p.r. switches turn from 0 dB to, say, 70 dB the attenuation applied to the received signal decreases.

(4) To make a measurement at other frequencies follow steps (1) to (3) selecting another frequency and band-stop filter. If the receiver sensitivity was made equal on all chosen ranges as detailed in Sect. 2.5 it will not be necessary to check receiver level when changing frequency.

It is not advisable to make an n.p.r. measurement such that the final position of the N.P.R./NOISE INPUT coarse control is fully clockwise. In this position the signal is connected via the fine attenuator only to the input of the band-pass filter: this is not such a good match for the system under test outside the pass-band frequencies. The return loss is as stated in Data Summary, Sect. 1.2, except for the most clockwise position of the coarse attenuator (corresponding to the unmarked position $x10^{-2}$ pW per channel).

Under certain circumstances, e.g. low noise level and high n.p.r., a reference mark low on the receiver meter should be used, say 30% f.s.d. However, the noise receiver should not be operated with the SET REFERENCE control in the extreme counter-clockwise position i.e. at minimum gain. This would result in the need for a higher noise loading of the band-pass filters and would provide a non-optimum condition for inherent intermodulation distortion.

Example of n.p.r. measurement:

A 24 channel system is being tested. From table 2.4, the noise generator is set to -31.5 dBm (or +4.5 dBm for a back-to-back test). The N.P.R. switches and SET REFERENCE control are set for meter REF reading then the skirts set to read 0 dB. If a band-stop filter at 16 kHz is switched in, the receive attenuators should be adjusted to restore the meter reference. Add the dB settings to read n.p.r. For a typical system, n.p.r. may be 52 dB (for a back-to-back test 71 dB).

Corrections for restoring generator output

For TF 2091B generators with a.l.c. (i.e. those with a single noise level control), the a.l.c. circuit operates to restore the noise power to its original level when the band-stop filter is switched in. Thus a.l.c. compensates for the insertion loss due to the energy in the slot and due to the equalizers, if any, in the filter and the generator meter reading does not change when the band-stop filter is switched in.

A correction is only necessary when maximum absolute accuracy is required. If third order non-linear distortion is present in the system, the noise power should be kept constant for minimum error in n.p.r. but, if second order distortion is present, the noise power density should be kept constant.

When third order distortion is predominant in the system under test, no adjustment is necessary since the generator a.l.c. restores the noise power to its original value. (Third order distortion is likely to apply to relatively long transmission line systems and where the loading level is relatively high).

When second order non-linear distortion dominates, the error is a minimum when the power density in the pass-band remains the same. (Second order distortion is likely to apply to radio systems and relatively short transmission line systems and to sub-normal signal loading levels.) To maintain the initial power density, the generator meter reading must be reduced by a small amount below the initial value. This correction depends on system baseband, filter frequency and filter characteristics. For 'B' filter sets reduce the meter reading by the amount given in Appendix II, and for 'A' filters by the amount in Appendix III.

Example of n.p.r. measurement with correction :

A 300 channel radio system is being tested. From table 2.4, the power level required is -26.2 dBm so the OUTPUT ATTENUATORS are set to give -0.2 dBm on the meter. A band-stop filter from set TK 2094/2 is switched in at 534 kHz; the a.l.c. of the generator automatically compensates for the insertion loss of the filter; the output power remains constant so the generator meter reading does not change. Only if second order non-linear distortion is dominant, is a correction necessary. From Appendix II, this is 0.10 dB so the meter reading should be set to read -0.30 dBm.

Use of RECORD output

Although the meter is the primary means of observing output on the receiver, the RECORD jack on the front panel permits the use of a recorder to monitor the output. The direct voltage available for a recorder is up to 2 V e.m.f. at a source impedance of several kΩ. Most 1 mA recorders are suitable.

2.7 DERIVING RATIO OF TEST-TONE LEVEL TO NOISE

It is possible to convert the noise power ratio, measured as in Sect. 2.6, into a ratio of test-tone level to noise (inherent and intermodulation) in a single channel. (This is a baseband measurement only. The multiplex noise must be checked separately and added on to get the figure for the system.)

Taking the multi-channel signal power which the generator has been adjusted to simulate, the proportion of it falling in the width of one channel is calculated. By expressing this in dB below test-tone level and adding it to the noise power ratio, the level of inherent and intermodulation noise in one channel below test-tone level is obtained. Expressed as it is, in dB, this is the required ratio. Thus the ratio of test-tone level to psophometrically weighted unwanted noise in one channel is given by:

$N + 10 \log (A/B) - P + 2.5$ decibels where

N = noise power ratio in dB,

A = bandwidth of multi-channel signal in kHz,

B = width of one channel in kHz,

P = multi-channel signal power simulated by the generator in dB above test-tone level.

2.8 MEASURING ABSOLUTE NOISE

(1) Turn all EQUALIZE RANGE SENSITIVITY controls fully clockwise.

(2) Switch OPERATE/STANDARDIZE switch to STANDARDIZE (the test equipment under test is automatically terminated in 75 Ω).

(3) Switch FREQUENCY SELECTOR switch to one of the frequencies to be standardized.

(4) Switch coarse and fine N.P.R./NOISE INPUT controls so that 1 pW is indicated on the red scale, engraved round each attenuator control, by the red coated button head on the pointer of each attenuator knob. In this initial setting the pointer of each knob indicates an engraved black spot.

(5) Adjust SET REFERENCE for a meter reading near the reference mark.

NOTE: If comparative measurements between channels are not required, omit steps (6) to (8).

(6) Switch the FREQUENCY SELECTOR to the other selected frequencies in turn and note which gives the minimum meter reading. Leave the switch in this position.

(7) Adjust SET REFERENCE control to give a meter reading on the reference mark.

(8) Switch the FREQUENCY SELECTOR to the other frequencies and, without touching the SET REFERENCE control, adjust the EQUALIZE RANGE SENSITIVITY presets to give a meter reading at the same reference mark. (Use only the preset for the selected frequency, e.g. adjust preset 4 when switched to frequency 4.)

The receiver is now set up to measure noise power provided the SET REFERENCE is not disturbed.

Continue to measure noise power using the calibration on the coarse and fine N.P.R./NOISE INPUT controls, proceeding as follows.

(9) Switch the N.P.R./NOISE INPUT controls to give an indication of 13 x 10^5 pW.

(10) Switch OPERATE/STANDARDIZE switch to OPERATE.

(11) Without adjusting the SET REFERENCE control adjust the coarse and fine N.P.R./NOISE INPUT to restore the reading on the meter to the reference mark.

(12) The input level is then found by multiplying the indicated red figures together, the answer being in unweighted pW/channel. For conversion from unweighted noise power per 3.1 kHz channel to psophometrically weighted power, voltage into 600 Ω and F1A-Line and C-Message weighting, see Figs. 2.10 and 2.11.

2.9 SELECTIVE LEVEL MEASUREMENT

With the FREQUENCY SELECTOR switch set to position 7, and an external local oscillator drive applied to the LO socket, the receiver may be used for selective measurements. The ext. l.o. source must be capable of supplying a drive level of 600 mV r.m.s., and should have low f.m. noise content.

NOTE: The receiver bandwidth is 2.2 kHz centred on the l.o. frequency but a 'hole' is present in the response within ±50 Hz of the centre frequency.

In this mode the receiver is less sensitive, i.e. approximately -85 dBm/kHz, and although the receiver is uncalibrated relative measurements are possible using the input attenuators.

Since a signal applied to the LO socket is fed direct to the mixer, protection of the r.f. input circuits which is normally provided by the band-pass filters is now longer present, and it is necessary to ensure that the total signal level at the mixer input does not exceed 3 mV r.m.s.

2.10 OUT-OF-BAND TESTING

The test set may be supplied with filters for out-of-band test frequencies, as recommended by the CCIR (398-2) see Table 2.5. Out-of-band tests are intended to enable maintenance measurements to be made under actual traffic conditions. The method involves the measurement of noise, including intermodulation products, in narrow bands whose centre frequencies are approximately 10% above the upper frequency limit and 10% below the lower limit of the traffic band. Measurements above the signal band are generally more sensitive to changes of thermal and intermodulation noise in the r.f. and i.f. parts of the equipment, whereas measurements below the band are more sensitive to changes in modulators and demodulators.

The receiver should be fitted with band-pass filters and oscillators at the out-of-band frequencies.

(1) Before making a measurement, the receiver must be standardized against the noise source, see Sect. 2.8.

(2) Turn the N.P.R./NOISE INPUT controls to indicate 13 x 10^5 pW and connect the receiver input to the system under test. It may be necessary to match the impedance of the test set to that of the

system under test. A band-stop filter at the out-of-band frequency should be connected in the input to the system to ensure that the out-of-band power at the receiver input is coming only from the system under test. The out-of-band frequency to be used can be found from Table 2.5.

(3) Set the OPERATE/STANDARDIZE switch to OPERATE.

(4) Restore the meter reading to the reference mark by adjusting the N.P.R./NOISE INPUT controls. The out-of-band noise power at the receiver input is found by multiplying the indicated red figures together, the units being unweighted pW per channel bandwidth.

For continuous monitoring it is convenient to use a pen recorder connected to the RECORD socket. If a two-channel system is available plotting the traffic level on the other channel will show if the variation of spurious noise is due to traffic level (i.e. intermodulation noise) or fading (thermal noise).

Table 2.5

Filter frequencies for out-of-band testing (CCIR Recommendation 398-2)

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Frequency limits of baseband (kHz)†	Centre frequencies of noise measuring channels (kHz) Below	Above (a)	(b)
24	12-108	12-108	10	119	
60	12-252	12-252	10	304	
	60-300	60-300	50	331	
120	12-552	12-552	10	607	600
	60-552	60-552	50	607	600
300	60-1300 64-1296	60-1364	50	1499	1549
600	60-2540 64-2660	60-2792	50	3200	3250
960	60-4028	60-4287	50	4715	4765
900	316-4188	60-4287	270	4715	4765
1260	60-5564 60-5636	60-5680	50	6199	6300
1200	316-5564	60-5680	270	6199	6300
1800	312-8204 316-8204	300-8248	270	9023	9073
2700	312-12388 316-12388	308-12435	270	13627	

† *Including pilots of frequencies which might be transmitted to line*

2.11 SYSTEM COMPONENT TESTING

The high output of the noise generator provides facilities to test video equipment, wide band amplifiers, passive apparatus etc., in conjunction with the noise receiver, an h.f. spectrum analyser or a tunable level meter.

In applications such as this the noise power ratio of the equipment under test may be nearly as good as that of the white noise test set.

Fig. 2.7 shows the effect of the difference between the back-to-back n.p.r. reading, and gives the correction factor to add to the measured value.

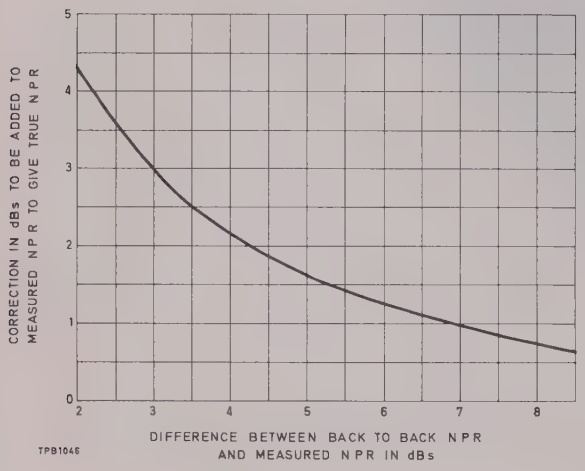


Fig. 2.7 Correction factor

2.12 MEASURING RESIDUAL SYSTEM NOISE

The residual system noise (or baseband intrinsic noise ratio) is a measure of the idle noise due to thermal noise carrier leaks, spurious f.m. in oscillators etc. It is defined as the ratio of noise in a test channel with all channels loaded to the noise in the test channel with all channel loading removed.

The procedure is therefore to measure the n.p.r. using Sect. 2.5 and 2.6. Then switch the generator NOISE ON/OFF switch to OFF and reset the receiver meter to the reference mark using the receiver input attenuator. The difference between the two readings is a measure of the residual noise of the system.

The difference between measured n.p.r. and residual system noise is a measure of the amount of spurious noise in the system caused by intermodulation distortion and crosstalk.

In addition to a measurement of residual noise a useful check is to examine the baseband signal using a spectrum analyser, such as M.I. type OA 1094 series with an L.F. Extension Unit TM 6448, to ensure that the residual noise measurement is not in error due to spurious signals (e.g. excessive carrier leaks, etc.).

2.13 ESTABLISHING THE SAFETY MARGIN OF A SYSTEM

The level of noise loading recommended by the CCIR, Table 2.4, simulated 'busy hour' traffic conditions. A graph of noise power ratio against noise loading will establish the safety margin in the system.

(1) Connect the noise generator to the transmitter and the noise receiver to the receiver of the system under test.

(2) Apply a noise signal equivalent to the minimum noise loading in the working region of the system and measure the n.p.r. (Sects. 2.5, 2.6).

Although the amount of thermal noise is generally constant, the proportion of thermal noise to r.f. signal level will vary for different r.f. levels; a different curve results (see Fig. 2.8). The level of r.f. signal should therefore be that for which the safety margin is required.

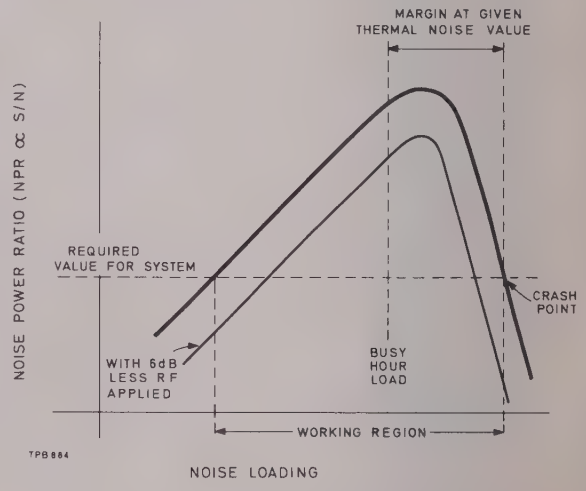


Fig. 2.8 System noise loading

(3) Repeat (2) increasing the noise loading in steps of say 1 dB and plot the curve of n.p.r. against noise loading. As can be seen from Fig. 2.8, the n.p.r. improves to a certain point as the proportion of thermal noise decreases; after this point intermodulation effects have an

increasing influence. A point is reached, called the 'crash point' when the n.p.r. is worse than that permissible for the system. The safety margin of the system can now be found by comparing the CCIR recommended level (Table 2.4) with the crash point.

2.14 USE OF CONVERSION CHARTS

In this manual there are several conversion charts. These are:

dBm to watts (Fig. 2.9)

The Noise Generator, type TF 2091B, is calibrated in dBm; this chart facilitates conversion to and from pW to extend the instrument's versatility.

To use this chart the power in watts can be read directly from the chart by looking at the adjoining column and reading off the power for a particular value in dBm.

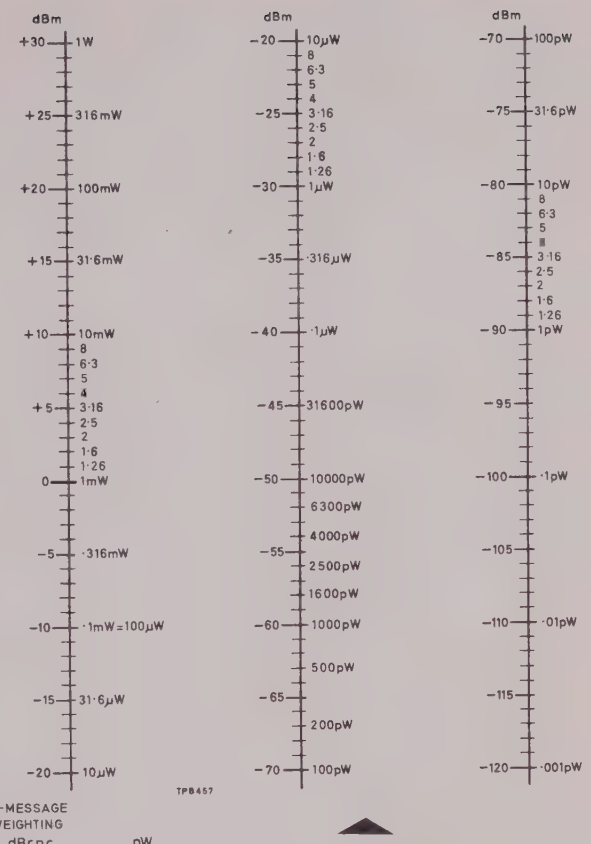
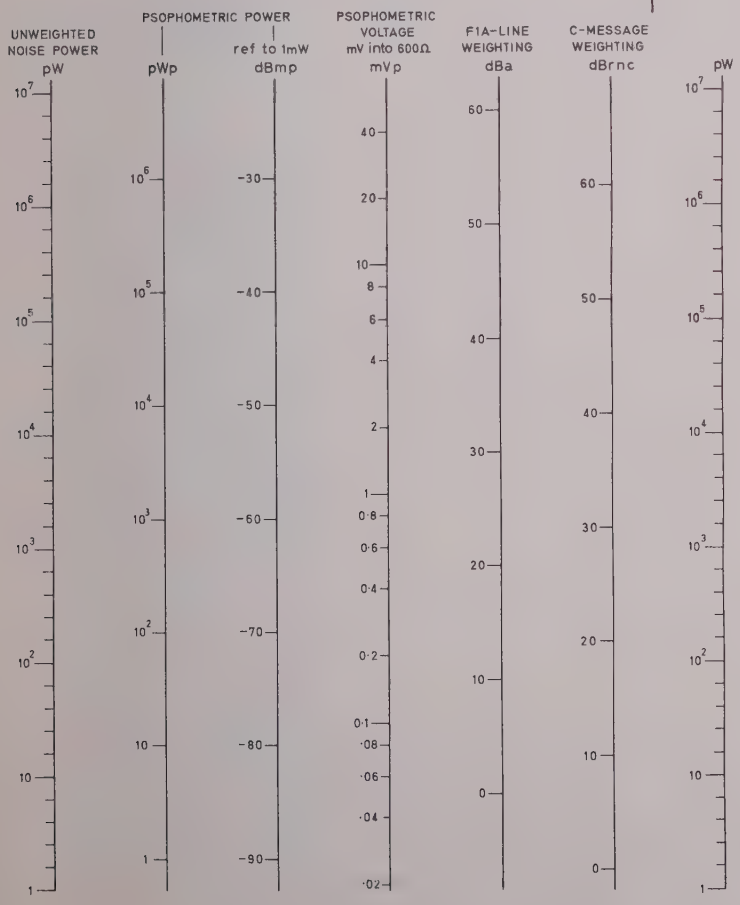


Fig. 2.9 dBm to watts conversion chart



Unweighted to weighted noise conversion charts (Fig. 2.10 and 2.11)

Fig. 2.10 covers a power range of 10^7 to 1 and is intended for approximate conversions. Use it by laying a rule, or straight edge, across the columns; the pW scale is repeated to ensure accurate alignment of the rule.

Fig. 2.10 pW to pWp, dBmp, mVp, dBa and dBrnc conversion chart (Power range 10^7 to 1)

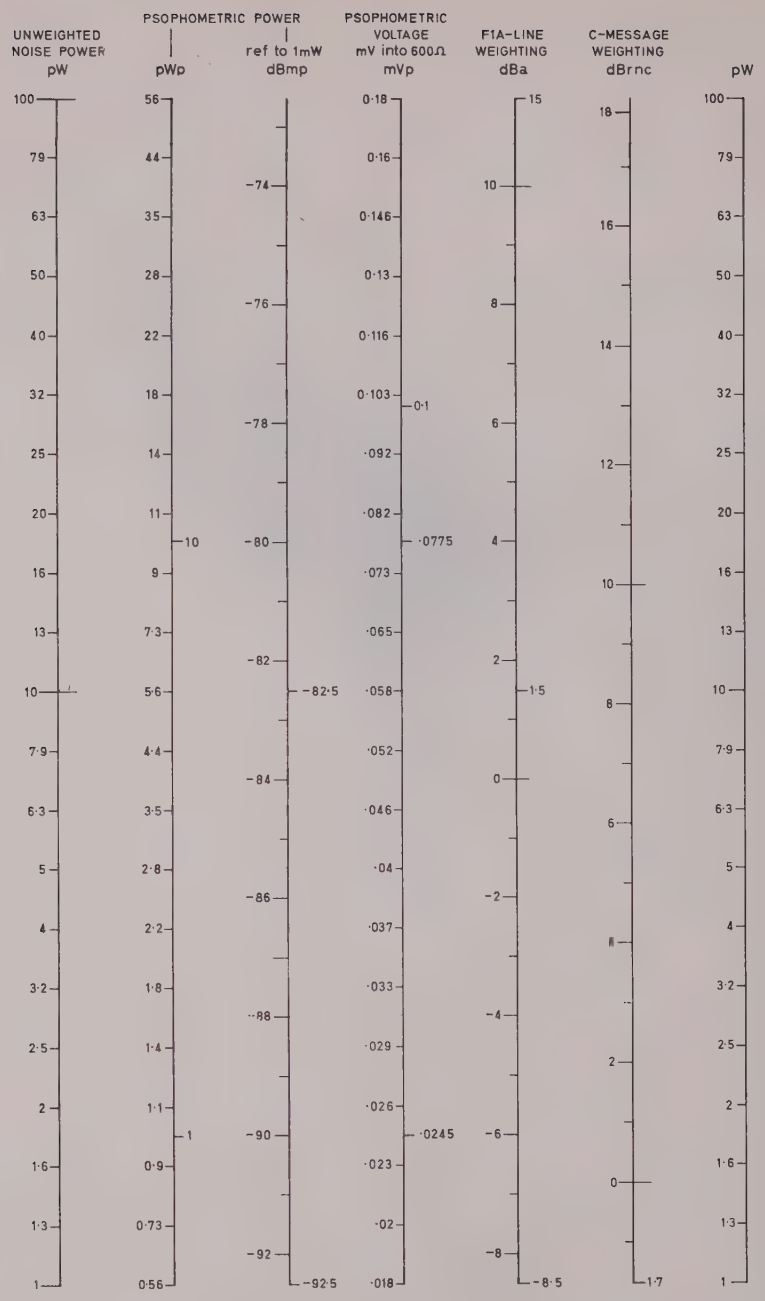


Fig. 2.11 pw to pWp, dBmp, mVp, dBa and dBrnc conversion chart (Power range 100 to 1)

Fig. 2.11, which covers a power range of 100 to 1, is used in the same way. It is intended for interpolation after an approximate conversion has been obtained from Fig. 2.10.

Example 1: to convert 10^4 pW into dBrnc

Using Fig. 2.10, 10^4 pW is seen to be equivalent to between 30 and 40 dBrnc. From Fig. 2.11, 10 pW is equivalent to 8.2 dBrnc. The value of 10^4 pW in dBrnc is therefore 38.2 dBrnc.

Example 2: to convert 6.3×10^3 pW to mVp

Using Fig. 2.10, 6.3×10^3 pW is seen to be equivalent to between 1 and 2 mVp. From Fig. 2.11, 6.3 pW corresponds to 0.046 mVp, and 63 pW to 0.146 mVp. Hence in this example 6.3×10^3 pW is equivalent to 1.46 mVp since from Fig. 2.10 the answer lies between 1 and 2 mVp.

N.P.R. distribution graph (Fig. 2.12)

The ratio of test-tone level to noise for a single channel can be obtained from the n.p.r. of the system. If the system satisfies the CCIR recommendation, the test tone signal to channel noise ratio will be equal to the value obtained from the graph.

Example: with a 2700 channel system and an n.p.r. of 50 dB, what is the expected test tone to channel noise ratio?

The point of coincidence of the 2700 channel curve and 50 dB n.p.r. is 67 dB on the signal to channel noise axis. Therefore 67 dB is the required value.

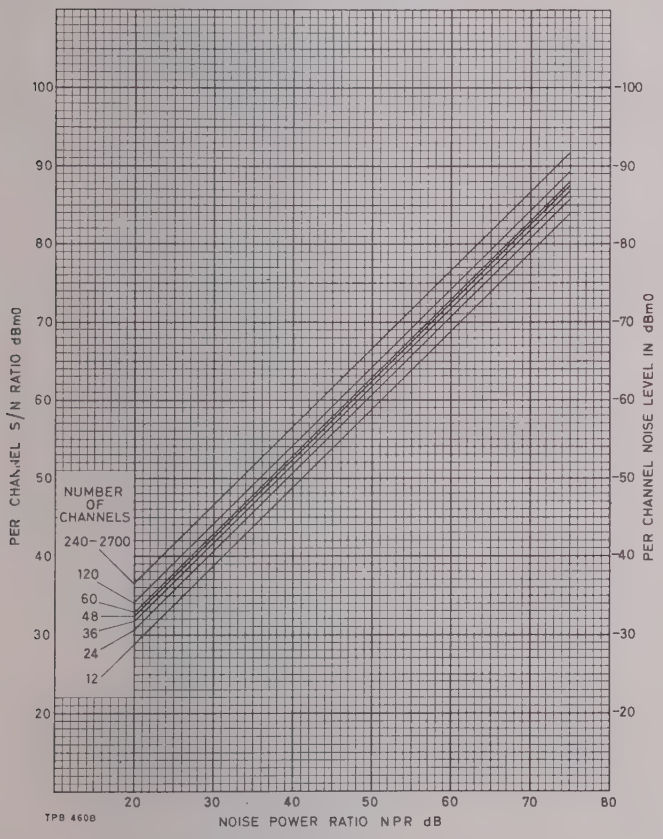


Fig. 2.12 N.P.R. distribution graph

dB to nepers (Fig. 2.13)

This chart is read by looking at the separate digits and adjusting the decimal point to the appropriate value. It can be used in two ways as follows:

Example 1: to convert 124 dB to nepers (approx.)

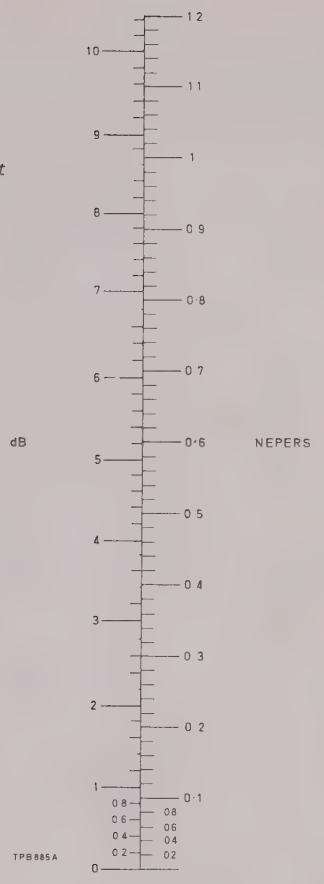


Fig. 2.13 dB to nepers conversion chart

From the chart, 1.24 dB is approximately equivalent to 0.14 Np, therefore 124 dB is approximately equivalent to 14 Np.

Example 2: to convert 124 dB to nepers (precisely)

10 dB = 1.15 Np

$\therefore$ 100 dB = 11.5 Np

2 dB = 0.23 Np

$\therefore$ 20 dB = 2.3 Np

4 dB = 0.46 Np

124 dB is therefore equivalent to

$$11.5 + 2.3 + 0.46 = 14.3 \text{ Np}$$

To convert a ratio expressed in decibels into a ratio expressed in nepers multiply by 0.1151.

Conversely to convert a ratio expressed in nepers into a ratio expressed in decibels multiply by 8.688.

Chapter 3

Technical description

3.1 NOISE GENERATOR TF 2091B

Noise Source TM 9505 —see Fig. 7.3

A white noise junction diode, MR200, is used to develop random noise with a substantially flat spectrum over the entire range of 10 kHz to 12.5 MHz. The diode is reverse-biased, and a current of the order of 1 mA from the 100 V supply flows through it, controlled by the potentiometer RV200.

VT200 is a buffer amplifier presenting 75 Ω to the output. RV201 presets the gain to determine the noise power output level (1 pW per 3.1 kHz bandwidth).

Low Level Amplifier TM 7638—see Fig. 7.4

From the noise source unit the signal passes to the low level amplifier, a three-stage high gain circuit. The first and the second stages have feedback loops to give stability with a wider frequency response.

The third stage is an emitter follower to provide a low output impedance. The input and output impedances are 75 Ω and the overall gain of the amplifier is 50 dB.

High Level Amplifier —see Fig. 7.5

Following the band-limiting filters the noise signal is amplified in the high level amplifier. The first stage, TR400, provides a constant 75 Ω input impedance. The second stage is a feedback pair TR401 and TR402, which provides wide band amplification. The third stage is a common emitter amplifier TR403, with frequency compensation provided by C407, and feeds emitter followers TR404 and TR405 in cascade which form the driver stage for the power output stage TM 9508.

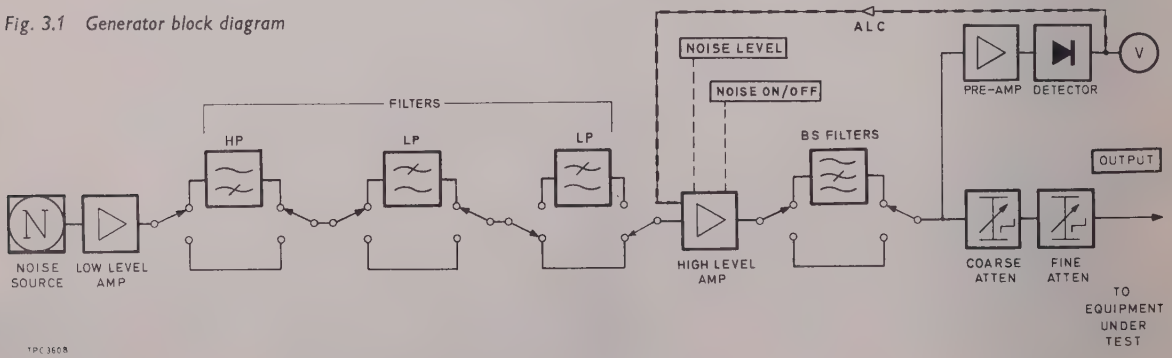
The overall gain of the amplifier is controlled by the a.l.c. circuit. A feedback voltage proportional to the meter current is amplified by the operational amplifier IC400 and compared, in the differential amplifier TR407 and TR410, with the voltage from the NOISE LEVEL control, R435. The differential amplifier output current flowing through R430 determines the bias on TR408 and hence its drain-source resistance. This adjusts the noise signal level from the potential divider formed by R405 and the drain-source resistance of TR408. L400 provides frequency compensation.

Power Monitor —see Fig. 7.6

Noise output is connected to the output terminal via the band-stop filters, and its level monitored at the output by the meter circuit.

The input to the meter circuit is first amplified by the cascoded pair TR500 and TR501 which also acts as an impedance converter on the input to a 5 dB step attenuator. The latter attenuates the signal to maintain the same operating level at the detector for generator outputs for the +10 dBm, +15 dBm and +20 dBm settings. TR502 is a buffer stage for the full-wave bridge detector. To maintain d.c. stability and detection efficiency over a wide range of frequencies and temperatures the detector circuit uses thin film resistors and matched diodes, all with closely matched temperature coefficients.

Fig. 3.1 Generator block diagram



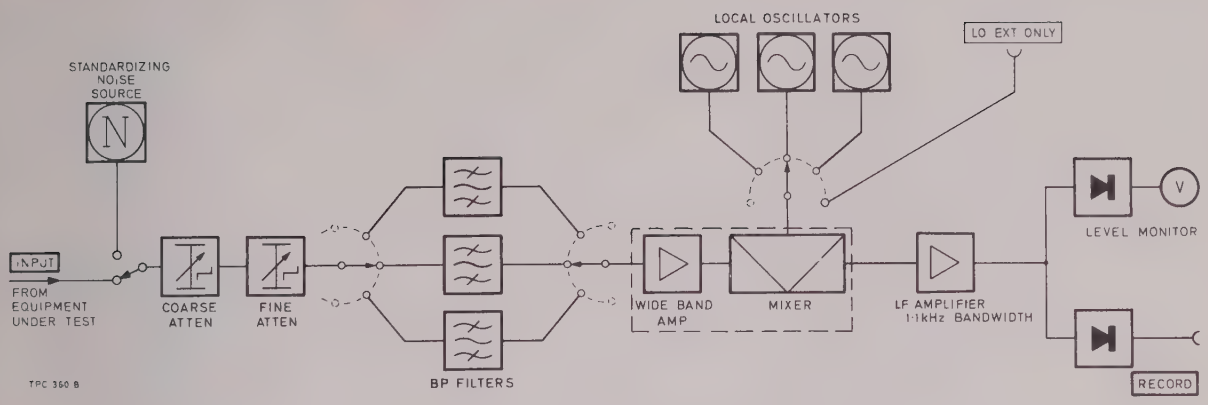


Fig. 3.2 Receiver block diagram

With the generator output loaded in 75 Ω the meter and attenuators indicate the true output power since the band-stop filters precede the meter circuitry.

Attenuators—*see Fig. 7.7 and Fig. 7.8*

The coarse attenuator provides 45 dB attenuation in four 10 dB steps and one 5 dB step. The fine attenuator provides 11 dB in 1 dB steps. A switch wafer, SC, on the spindle of the coarse attenuator also selects the meter sensitivity on the ADD 10 dB, 15 dB and 20 dB ranges.

Power Supply TM 7594—*see Fig. 7.2*

The input transformer has two primary windings which are arranged, by switch SB, in series for the 230 V setting and in parallel for the 115 V setting. Both line and neutral supply connections are fused. The neon pilot lamp is across one half of the primary winding.

The secondary is centre-tapped and drives a series regulator circuit through full-wave rectifiers MR100 and MR101. The regulated output is at 54 V, and two other potentials are available; 25 V tapped from the 54 V line, and 100 V obtained by superimposing 45 V on the 54 V supply. The 45 V line is derived from the secondary voltage by a half-wave rectifier MR102, and is stabilized by MR103, 104 and 105 in series.

VT1 is the series stabilizer, and MR106 and 107 provide a reference potential for the emitter of VT101, the error signal amplifier. RV101 sets the output voltage level; hum and output fluctuations pass via VT100 to the base of VT1. RV100 is adjusted for minimum ripple and RV102 adjusts the 25 V line voltage.

Resistor R1 is fitted to discharge C1 when the supply is switched off. Resistor R3 is fitted to discharge C1 when fuse FS3 blows; this minimizes the risk to transistor VT1 should the fuse be replaced immediately after failure.

3.2 NOISE RECEIVER TF 2092B

Standardizing Noise Source TM 7670—*see Fig. 7.11*

A semiconductor noise diode, MR700, has a preset current controlled by RV700 passing through it in the reverse biased condition. As a result the diode emits noise in the range 10 kHz to 13 MHz, which is then fed through a common emitter stage, VT700. The noise output level is adjusted in calibration by selecting the value of R705 in the emitter stage, the output at the high end of the frequency spectrum being controlled by the capacitor, C707. With the output terminated in 75 Ω a noise reference level of -90 dBm per 3.1 kHz bandwidth (1 pW per channel) is produced.

Mixer Unit 46778-005—*see Fig. 7.14*

After passing through the input attenuators and a band-pass filter, determined by the frequency selector switch, the noise input from the equipment under test reaches a two-stage wide band amplifier whose input impedance is 750 Ω. A feedback pair TR300, TR301, provides voltage amplification and is designed for a low level of inherent noise. The second stage, an emitter follower, provides a low impedance to drive the mixer circuit which follows. The gain of the amplifier is preset to 22 dB by R304 in the feedback loop of the first stage.

A high-pass filter (C307, L301, C308) attenuates all frequencies below 10 kHz at the

mixer input to reduce any unwanted noise introduced in the wide band amplifier. The mixer TR303 presents an input impedance of 75 Ω.

The local oscillator signal, at the centre frequency of the r.f. pass band, is fed to the emitter of TR303 (mixer stage) via PL300 and the emitter follower TR304. R313 adjusts the current in TR303 for optimum conversion conductance. The low frequency output is taken from SKT301 to the l.f. amplifier TM 9514.

Local Oscillator Box TM 9517—*see Fig. 7.9*

The local oscillator box contains six slots for plug-in local oscillator boards, see below and the following circuitry.

The frequency selector switch SC, selects the appropriate local oscillator by connecting the h.t. to that particular oscillator board. The local oscillator signal is then connected to the mixer via SKT606 and to the output socket, SKT609, on the front panel where it is available for external use. In position 7, an external oscillator may be connected directly to the mixer via the socket on the front panel.

The equalize range sensitivity potentiometers number 1 to 6 on the front panel, are selected by switch SC and are effectively variable resistors in series with the set reference control. The resistors have minimum resistance (which is the condition for maximum sensitivity) when the front panel controls are fully clockwise.

Local Oscillator Boards

A wide selection of oscillator boards is available to suit channel frequencies called for by CCIR Recommendations 399 (1963), 399-1 (1966) and 398-2 (1970) and by INTELSAT IV. The boards

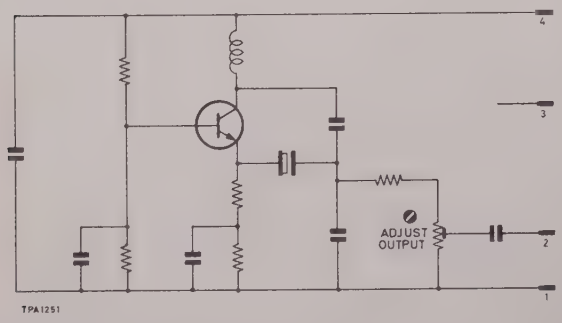


Fig. 3.3 Typical oscillator circuit

54493 series, 54496 series and TM 7793, 94, 95 series are listed in Appendix I. The 54493 series are mainly crystal type above 98 kHz. A typical circuit of a 54493 series oscillator is shown in Fig. 3.3.

L.F. Amplifier TM 9514—*see Fig. 7.15*

The l.f. amplifier comprises two active filter stages each containing three transistors and a feedback amplifier stage also containing three transistors. A separate buffer stage provides current drive to the record output.

The active filter part of the amplifier has an upper 3 dB cut-off frequency of 1.1 kHz and an attenuation frequency characteristic of 24 dB/octave above the cut-off frequency. The final amplifying stage (VT406, VT407, VT408) feeds the detector circuit and incorporates overall a.c. feedback via R424 and d.c. feedback via R423. MR400 and MR401 are the meter circuit detection diodes whilst MR402, MR403 and MR404 are used to protect the meter against excessive voltage transients. VT409 is an emitter follower supplying the voltage doubler network MR405, MR406, the resultant d.c. being smoothed and used to drive a 1 mA d.c. recorder.

Power Supply TM 7710—*see Fig. 7.10*

The input transformer has two primary windings which are arranged in series or parallel by switch SB. With switch SB in the 230 V setting mains supplies of 190 to 260 V can be used with the windings in series. Both line and neutral supply connections are fused. The neon pilot lamp is across one half of the primary windings.

One of the secondary windings is centre-tapped and the output taken through MR100 and MR101 to the series regulator circuit formed by the voltage reference Zener diode MR102, and the three transistors VT1, VT100, VT101. The other secondary winding produces 100 V d.c. from a half-wave rectifier MR103 which is stabilized by a chain of Zener diodes MR104, MR105, MR106, MR107, MR108. This voltage is used to provide bias for the noise diode in the Standardizing Noise Source TM 7670.

RV100 is provided to allow adjustments to be made for minimum ripple, and RV101 sets the output level at 25 V.

The reservoir capacitor, C1, is fitted with a parallel resistor to discharge it when the supply is switched off - a necessary safeguard in a semiconductor instrument.

The 25 V line is fused. This fuse must not be removed or replaced until the reservoir capacitor has had time to discharge.

3.3 FILTERS

All filters have 75 Ω characteristic impedance except for band-pass filters which have 75 Ω input impedance, 750 Ω output impedance.

There are four main groups of filters used in the test set for in-band testing.

a)	High-pass TK 2096 series	These are used in the generator and are individually switched.
b)	Low-pass TK 2095 series	
c)	Band-stop 54491 series	
d)	Band-pass 54492 series	These are used in the receiver and are not individually switched.

All the above are 'B' version filters and meet requirements of CCIR Recommendation 399-1 (1966).

Out-of-band filter sets TK 2084 series, conform to CCIR Recommendation 398-2 (New Delhi 1970). Like the 'B' version filters they can be used in OA 2090B and earlier test sets, viz OA 2090 and OA 2090A.

Filters : TM 7728 series, High-pass Filters,
TM 7720 series, Low-pass Filters,
TM 7729 series, Band-stop Filters,
TM 7730 series, Band-pass Filters,
designed for other versions of the test set may be used in the OA 2090B. They meet the less stringent requirements of CCIR Recommendation 399 (1963).

In all the filters, the circuitry which consists of combinations of inductors, capacitors, and in some cases crystals, is contained on printed boards. The switched filters contain a bulkhead behind the front panel to which is attached the rocker mechanism actuating two micro-switches.

In the 'Filter-in' position the filter is switched between input and output sockets. In the 'Filter-out' position the circuit is replaced by a shorting link with a shunt 20 pF capacitor to overcome the mismatch due to the inductance of the link.

High- and low-pass filters

The high-pass and low-pass filters are generally of the coil-capacitor type. The high-pass filters are based on m-derived Darlington

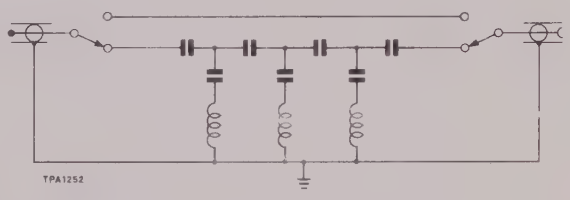


Fig. 3.4 Typical high-pass filter circuit

types and consist of capacitance-coupled series tuned L-C shunt circuits. A typical high-pass filter circuit is shown in Fig. 3.4.

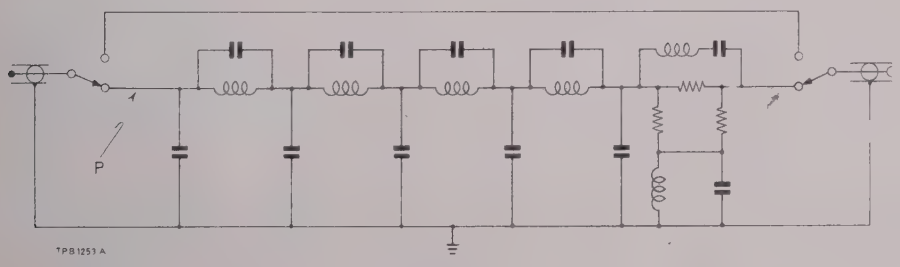


Fig. 3.5 Typical low-pass filter circuit

The low-pass filters are of the Tchebyshev type and consist of parallel tuned circuits in the series arms with capacitance shunt circuits. Equalization at the output is used to ensure minimum ripple in the pass band. A typical low-pass filter is shown in Fig. 3.5.

If 'A' version low-pass filters above 8 MHz are used in a generator with a.l.c., the filters should be fitted with a 5 dB resistive pad at their inputs to facilitate satisfactory a.l.c. performance.

This can be done by inserting a π resistor network (270 Ω, 47 Ω, 270 Ω) in the filter unit, breaking the track at point P - see Fig. 3.5.

Band-stop

The characteristics of the band-stop filters are given in the Data Summary.

54491 series (part of TK 2094 series) see Fig. 1.2
TM 7729 series see Fig. 1.4
54494 series (part of TK 2084 series) end of Sect. 1.2

The filters all have 75 Ω input and output impedances. 54491 series filters employ amplitude equalizers, where necessary to give maximum flatness of the pass band. The consequent insertion loss, which depends on the type of filter, is typically 1 dB to 2 dB. Of the 54494 series filters, those above 4715 kHz employ amplitude equalizers with typical insertion losses of 0.5 dB.

A diversity of circuit configurations is used for the band-stop filters. Most are L-C types but the higher frequency (3886 kHz and above) filters of the 54491 series are crystal types. It may be noticed that some filters are hermetically sealed. This is necessary on certain designs to maintain their high Q's under conditions of high humidity.

If a filter is suspected of being faulty its characteristic can be checked using a 75 Ω selective measuring set and, if the unit is not sealed, by physical inspection. Specialized test gear is required to align the filters and it is strongly advised that no adjustment be attempted. The faulty filter should be returned to our Service Division. No circuit information is given in this manual. See other manuals.

It should be noted that, being crystal filters, the higher frequency filters of the 54491 series exhibit spurious responses at frequencies just above the stop band and at approximately three times the stop band frequency. These spurious responses take the form of a scattering of very narrow rejection bands, each a few kHz wide and with amplitudes less than 10 dB. Their effect on an n.p.r. measurement is negligible since the power extracted by the spurious stop bands is less than 0.05 dB.

Band-pass

Band-pass filters 54492 series, 54495 series and TM 7730 series (listed in Appendix I) each have a pass band which is narrower than the slot of its corresponding band-stop filter. The characteristics of the band-pass filters are derived from the specifications of the band-stop filters and the requirements of the receiver.

In general the characteristic of a band-pass filter is such that, when combined with the appropriate band-stop filter, the all band rejection exceeds 50 dB. Input impedance is 75 Ω but output impedance is 750 Ω. Power insertion loss at the centre frequency depends on the filter type and is up to 6 dB for the 'B' version filters*. For 'A' filters power insertion loss is up to 16 dB. Attenuation relative to the pass band is at least 50 dB.

There is no common circuit configuration for band-pass filters and no circuit information is included in this manual. Certain filters of the 54492 series employ crystals in order to achieve the necessary narrow characteristics. To protect the coils under high humidity conditions, hermetic sealing is again necessary on some filter boxes.

The response of a band-pass filter can be checked using a 75 Ω selective measuring set and a 750 Ω to 75 Ω resistive matching pad. As with band-stop filters no adjustment should be attempted and a faulty filter should be returned to our Service Division.

*534 kHz band-pass filters with serial numbers up to 175043 had 10 dB insertion loss.

Chapter 4

Maintenance

4.1 GENERAL

This chapter is for use in fitting filters and local oscillators; for carrying out a functional test of the white noise test set and for checking its performance. To realign the test set or to fault-find, refer to Chapter 5. In case of difficulty please contact our Service Division or your nearest Agent. Always mention the type numbers and serial numbers of your instruments.

CAUTION

Semiconductor devices are used throughout the test set and, although they have inherent long term reliability and mechanical ruggedness, they are easily damaged by overloading, reversed polarity and heat or radiation. Avoid prolonged soldering, strong r.f. fields or short circuits. Do not use insulation testers. Always allow a few seconds for the h.t. electrolytic capacitors to discharge after switch off before attempting any operation on the internal components.

4.2 FUSES

All the fuses are set in the rear panel. The noise generator has four: two supply fuses rated at $\frac{1}{2}$ A for 240 V or 1 A for 110 V, and two h.t. fuses, of 50 mA and $\frac{1}{2}$ A rating.

The noise receiver has three fuses, two supply fuses of 100 mA (or 250 mA for 110 V supplies) and a 250 mA h.t. fuse.

It is not necessary to remove the case or cover to reach the fuses but it is essential to switch off the supply, unplug the supply lead and wait at least 30 seconds before fitting a new fuse.

4.3 REMOVING THE CASE

The case is held on by four 2 BA screws in the back. The rack-mounting version has top and bottom covers secured by a screw at each corner. Generator and receiver have similar covers or cases; the bottom plate of the case is separately detachable by undoing two Dzus fasteners and slipping the plate out from under the retaining bar.

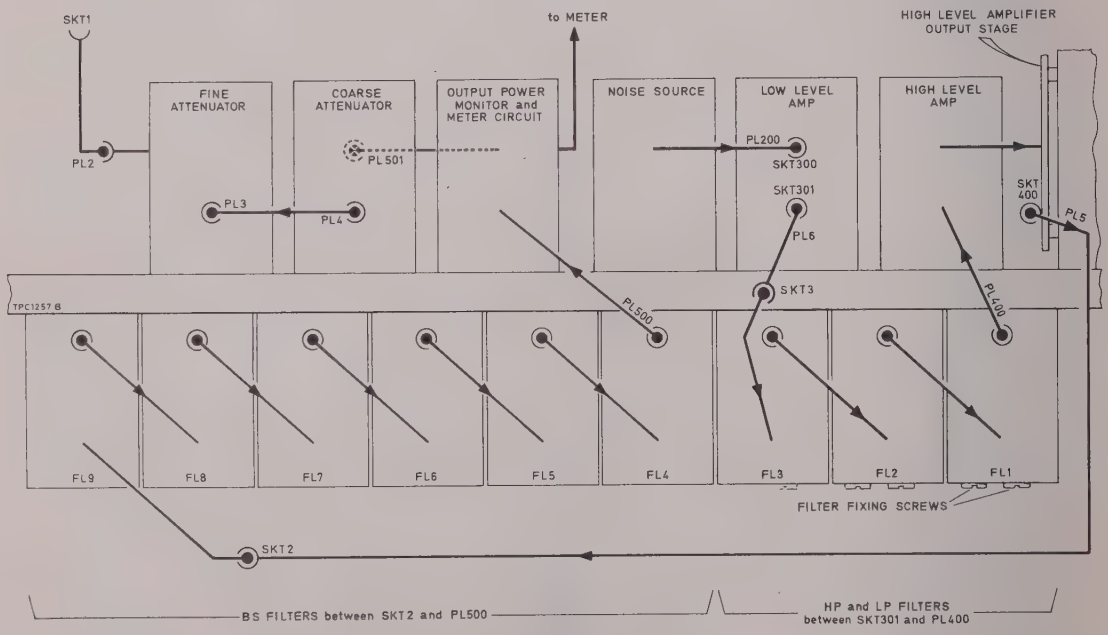


Fig. 4.1 Generator filter connections

4.4 FITTING GENERATOR FILTERS

The noise generator can accommodate a selection of low-pass, high-pass and band-stop filters, up to a total of nine. Low-pass and high-pass filters are connected in cascade between SKT3 on the right-hand bracket and PL400 on the high level amplifier as shown in Fig. 4.1. Band-stop filters are fitted in cascade between SKT2 on the left-hand bracket and PL500 on the power monitor unit. Bracket positions as viewed from the front with instrument upside down.

Switch off the supply and take out the mains plug. Remove the bottom plate of the case.

If there is a space, remove the blank panel unit after undoing the single fixing screw; if not, remove the unwanted filter. Each filter is held in place by two long spring-loaded captive screws passing through the body of the filter into the chassis. Noise generator filters make electrical connection by means of a socket and trailing plug; Fig. 4.1 shows the correct connections for each type of filter, and these must be observed. High-pass and low-pass filters come before the high level amplifier and band stop filters come after it.

NOTE: Do not undo the screws in the front panels of the filters or blank panels.

4.5 FITTING RECEIVER FILTERS

The noise receiver can accommodate up to six band-pass filters which are connected to adjacent pairs of plugs from the oscillator unit as shown in Fig. 4.2.

Switch off the supply, and take out the mains plug. Remove the bottom plate of the case. The position for the new filter will be occupied by either an old filter or a blank panel at the front and a cable clip at the rear, which must be removed. Filters are attached by two long spring-loaded captive screws passing through the bodies of the filters into the chassis; blank panels and cable clips are held by short screws into the same holes in the chassis as are used for mounting the filters.

Screw the new filter into place. Each filter position has its own pair of leads which carry sleeves with numbers corresponding to the six positions. On the back of each filter are two BNC sockets, labelled input and output. The leads come from the frequency selector switch box as shown in Fig. 4.2; all the input leads originate from one slot, and the output leads from another.

NOTE: Do not undo the screws in the front panels of the filters or blank panels.

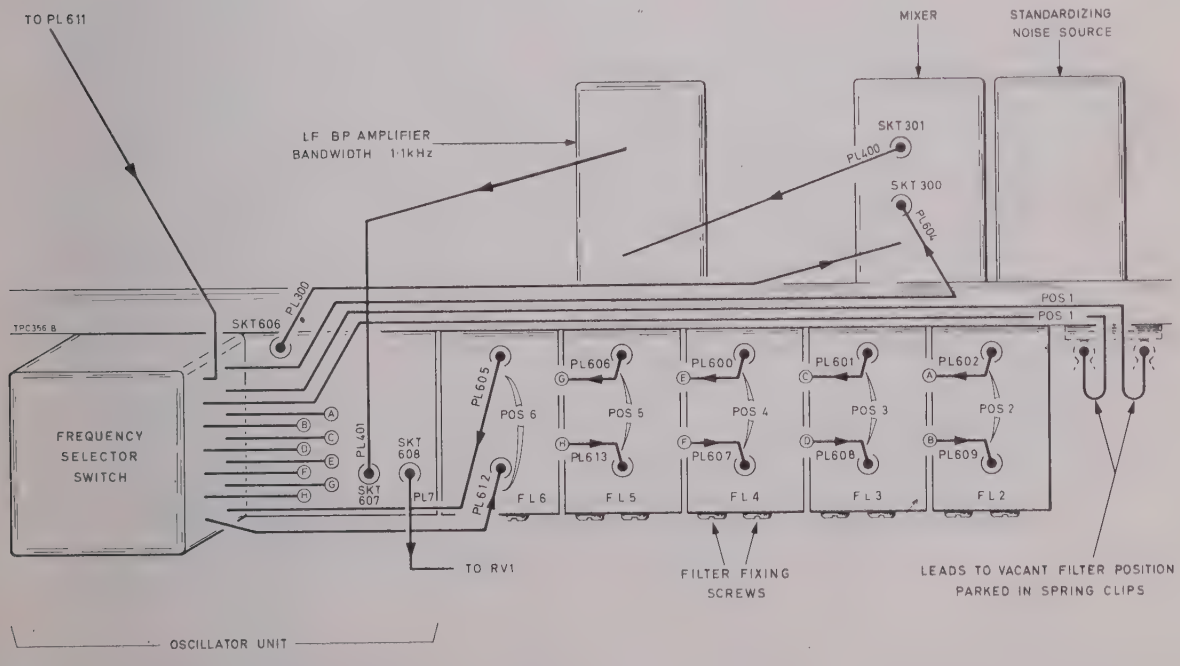


Fig. 4.2 Receiver filter connections

For example, for a filter fitted in the No. 2 position the leads to it will be marked '2'; the lead to its input socket originates from the slot labelled filter input leads and the lead to the output socket from the slot labelled filter output leads. A filter connected the wrong way round will not function. Note that each band-pass filter has an associated local oscillator board which must also be fitted in the appropriate position. (See Fig. 4.3.)

Attach the cable clip to one of the tapped holes in the rear panel. Never leave cables loose inside the case.

4.6 FITTING RECEIVER LOCAL OSCILLATOR BOARDS

Switch off the supply, and take out the mains plug. With the bottom plate of the case removed, the oscillator box which contains the frequency selector switch is accessible. It may be opened by undoing a single Dzus fastener.

Inside the box the oscillator boards fit into the sockets, and are steadied by slotted plastic guides. The sockets are numbered from one to six to correspond to the setting of the frequency selector switch and the band-pass filter. A local oscillator board fitted in a certain socket will be selected with the appropriate filter when the switch is set to the corresponding number.

Press the board firmly into its socket and screw the oscillator box lid down to hold it in place.

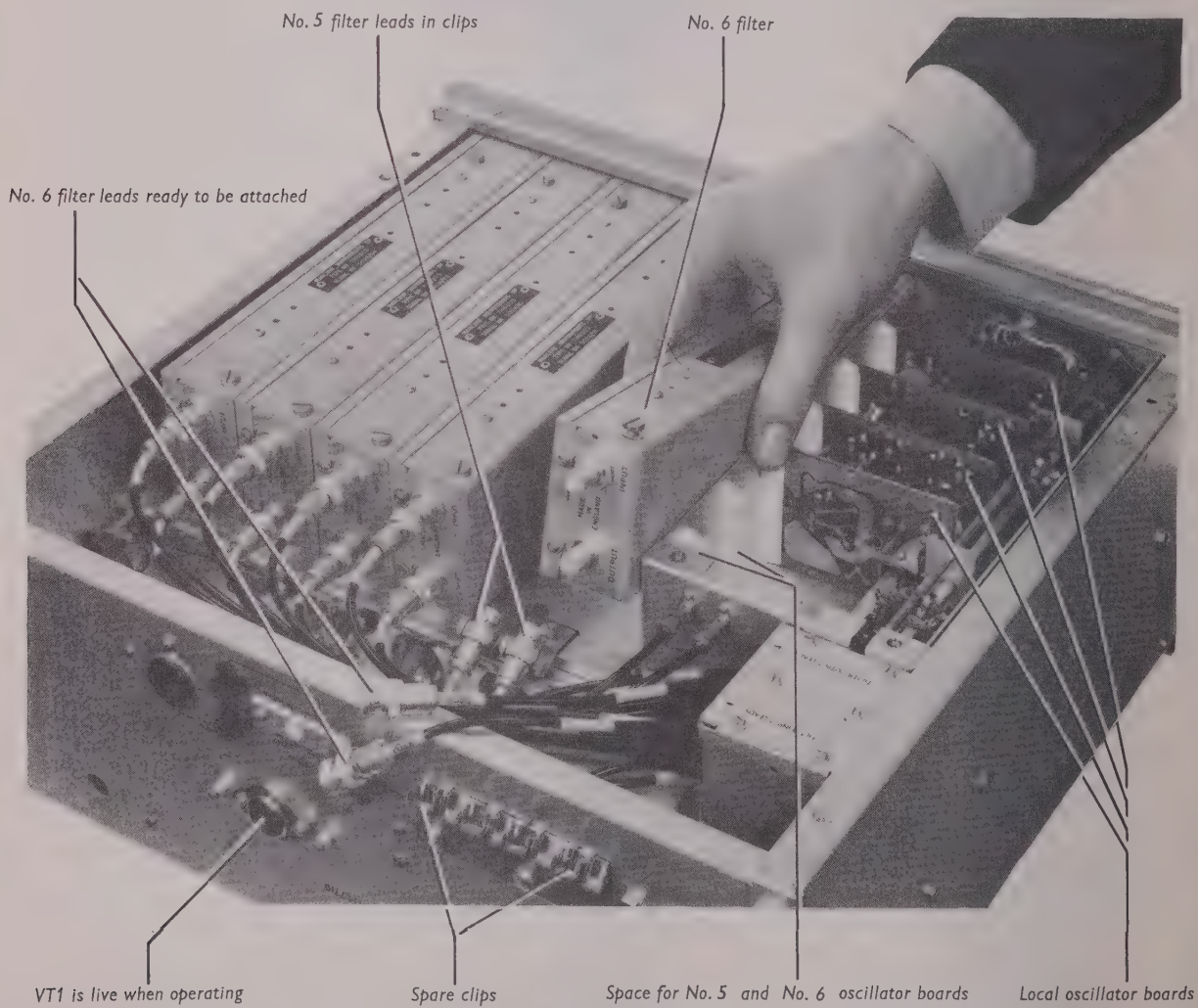

No. 5 filter leads in clips
No. 6 filter
No. 6 filter leads ready to be attached
VT1 is live when operating
Spare clips
Space for No. 5 and No. 6 oscillator boards
Local oscillator boards

Fig. 4.3 Changing receiver filters

4.7 TEST EQUIPMENT

There follows a list of test equipment which is required to carry out performance tests and realignment procedures:

(a) Multi-range d.c. voltmeter, 20 kΩ/V; e.g. Avometer model 8.

(b) Variable mains transformer; e.g. Variac.

(c) Sweep generator, 10 kHz to 13 MHz, with differential detector facility; e.g. M.I. type TF 1099.

(d) Oscilloscope with 15 MHz bandwidth.

(e) R.F. step attenuator. 0 to 60 dB in 1 dB steps; e.g. M.I. type TF 2163 or TF 1073A.

(f) Standardized selective level meter, 75 Ω, effective bandwidth between 2 kHz and 4 kHz, meter time constant approx. 1 sec.: e.g. Siemens Rel. SD 335.

(g) Standardized power meter, 75 Ω, for use up to 15 MHz. 1 mW range with an accuracy of 0.1 dB.

(h) Signal generator. 10 kHz to 15 MHz; e.g. M.I. types TF 144H or TF 2002AS with 50/75 Ω matching pad.

(j) Counter 10 kHz to 12.5 MHz; e.g. M.I. types TF 2411 or TF 2410.

(k) Valve voltmeter, d.c. to 15 MHz; e.g. M.I. type TF 2604.

(l) Video oscillator covering baseband frequencies.

(m) Differential d.c. voltmeter; e.g. M.I. type TF 2606.

(n) R.F. step attenuator. 0 to 20 dB in 1 dB steps with accuracy of 0.05 dB.

(p) V.S.W.R. measuring test gear, e.g. Telonic Rhotector and set of standard terminations.

4.8 FUNCTIONAL CHECK

The following tests verify that the test set functions satisfactorily.

4.8.1 Back-to-back test

(1) On the noise generator switch IN a high-pass and a low-pass filter appropriate to the required test frequency. Switch out all band-stop filters.

(2) Set the generator output to the dBm0 level given in column 3 of Table 2.4 using the OUTPUT ATTENUATORS and the NOISE LEVEL control.

(3) Set the receiver FREQUENCY SELECTOR switch to the channel corresponding to the required test frequency.

(4) Connect the generator OUTPUT socket to the receiver INPUT socket by means of a 75 Ω coaxial lead.

(5) Set the OPERATE/STANDARDIZE switch to OPERATE.

(6) Turn the appropriate EQUALIZE RANGE SENSITIVITY control fully clockwise.

(7) Switch the coarse N.P.R./NOISE INPUT control to indicate 0 dB with the red line on the skirt coinciding with the red spot on the knob.

(8) Switch the fine N.P.R./NOISE INPUT control to indicate 0 dB.

(9) Adjust the SET REFERENCE control to give a meter reading on the REF mark.

(10) Switch IN the band-stop filter at the same frequency as that selected in step (3).

(11) Adjust the coarse and fine N.P.R./NOISE INPUT controls so that the receiver meter indication is restored to the REF mark. The n.p.r., which is obtained by adding the dB readings, should be at least 67 dB (with 'A' filters at least 75 dB above 50 kHz).

4.8.2 Generator noise characteristics

Frequency characteristic

Within the baseband of the system under test, the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz does not vary by more than ±0.5 dB.

Connect the selective level meter to the OUTPUT socket, switch out all the filters and set the output level to +15 dBm. The noise output level can be checked at various frequencies; in any base bandwidth the variation of level should not exceed 1 dB overall.

Amplitude distribution

In addition to its uniform frequency spectrum, white noise has a random distribution of amplitudes, i.e. the probability that the amplitude of the noise at any instant lies between two given levels obeys a normal Gaussian curve. Specialized analysis equipment is necessary to establish this, but a visual check can show whether operation is satisfactory.

Set the generator to any level up to +15 dBm, select band-limiting filters for maximum base bandwidth and connect the output via a 75 Ω load to an oscilloscope. With the time base off and trace centralized, a display should be observed with positive and negative peaks of equal amplitude, a gradual decrease in brilliance towards each peak and no evidence of jitter, transients or clipping.

4.8.3 Receiver sensitivity

Sensitivity is better than -130 dBm/kHz (-125 dBm/kHz with 534 kHz Filter TK 2094/2 or -120 dBm/kHz with 'A' Filters).

The sensitivity figure is equivalent to the inherent noise power density of the receiver and is the minimum input power density required to increase the standing meter reading by 3 dB, i.e. increase it by $x\sqrt{2}$. To improve measurement accuracy the following method determines the minimum input power density required to increase the standing meter reading by 12 dB, i.e. by a factor of 4.

(1) Select OPERATE and turn all EQUALIZE RANGE SENSITIVITY presets fully clockwise. Rotate the skirt of the coarse attenuator until the red line on the skirt coincides with the red spot on the knob.

(2) Switch to the first frequency to be measured and with no input connected adjust the SET REFERENCE control to give 10% of f.s.d. on the meter.

(3) Select STANDARDIZE and, without altering the SET REFERENCE control, adjust the attenuators until a reading as close as possible to 40% f.s.d. is obtained.

(4) The N.P.R./NOISE INPUT should indicate less than 68 dB (less than 73 dB with 534 kHz Filter TK 2094/2 or less than 78 dB with 'A' Filters).

(5) Repeat for other frequencies.

NOTE: For an n.p.r. indication of 68 dB actual attenuation is 23 dB. Since the standardizing noise source is -95 dBm/kHz, the noise input would be -118 dBm/kHz.

4.9 PERFORMANCE TESTS

This section provides detailed information for checking the performance of a white noise test set. To realign the test set use Chapter 5. Performance limits quoted are for guidance only and should not be taken as guaranteed specifications unless also quoted in the Data Summary.

NOISE GENERATOR TF 2091B

4.9.1 Noise output

Test equipment : items f, g.

The power output available from the noise generator will depend on the noise bandwidth, which is determined by the high- and low-pass filters used. Maximum power is +20 dBm without clipping and the levels shown in Table 2.4 should be obtainable.

(1) Switch IN a pair of high- and low-pass filters, switch out all band-stop filters. Check that the OUTPUT ATTENUATOR and NOISE LEVEL controls can be set to the dBm0 level given in Table 2.4, column 3.

Noise band characteristics should be checked as in Sect. 4.8.2 using a selective level meter and an oscilloscope. If unsatisfactory set up generator as in Chapter 5.

4.9.2 Output level accuracy

Test equipment : items g, e.

Output level accuracy at 0 dBm is ±0.3 dB. Additional error at other levels: ±0.5% of fine attenuator dB setting, ±0.5% of coarse attenuator dB setting, ±0.1 dB.

(1) Measure the output level with the OUTPUT ATTENUATORS set to 0 dB and the meter set to 0 dBm, using the standardized power meter, and observing the CAUTION below.

CAUTION:

Do not switch any generator control or switch any filter in or out with the standardized power meter connected, since the a.l.c. circuit could cause the output to rise momentarily and overload the power meter.

(2) The attenuators can be functionally checked by monitoring the output with a step attenuator and a Noise Receiver TF 2092B. Set to ADD 5 dB (actual attenuation zero), adjust NOISE LEVEL control for 0 dBm meter reading, then switch through the 0 dB and all the SUBTRACT positions checking the attenuation. Also check the ADD 10 dB, ADD 15 dB and ADD 20 dB positions; the a.l.c. increases the noise level for these settings so that the meter still indicates 0 dBm.

(3) With a meter indication between -1 and +1 dB the a.l.c. circuit should restore the power level to within -0.25 dB of the original level when a band-stop filter is switched in.

(4) If the above checks are unsatisfactory refer to Sect. 5.3.4 and 5.3.5.

4.9.3 Output impedance and return loss

Test equipment : item p.

Output impedance is 75 Ω and return loss greater than 20 dB when the attenuators are set for 0 dB and below.

Switch the NOISE ON/OFF switch to OFF and switch out all band-stop filters. Measure the v.s.w.r. at the output socket; it should be better than 1.2:1 at 13 MHz. If it is not, refer to Sect. 5.3.4.

NOISE RECEIVER TF 2092B

4.9.4 Receiver bandwidth

Test equipment : item h.

Effective receiver bandwidth is nominally 2.2 kHz and is determined by the bandwidth of the l.f. amplifier, slightly modified by the bandwidth of the band-pass filter. Since the l.o. frequency is at the centre frequency of the r.f. pass band, the bandwidth of the l.f. amplifier is only 1.1 kHz i.e. half the receiver pass band. The receiver bandwidth may be determined using a signal generator to plot the relative sensitivity in the neighbourhood of the frequency selected.

4.9.5 Sensitivity

Receiver sensitivity should be measured as in Sect. 4.8.3.

4.9.6 Input impedance and attenuators

Test equipment : item p.

Input impedance is 75 Ω and return loss greater than 20 dB for all positions of the input attenuator when the indicated level exceeds 0.1 pW. Maximum input attenuation is 91 dB.

Select OPERATE and set the attenuator to indicate a level greater than 0.1 pW. Measure the v.s.w.r. at the input socket which should be better than 1.2:1. With the switch set to STANDARDIZE the v.s.w.r. should be better than 1.07:1.

If this specification is not met in the OPERATE position the likely fault is in the attenuators in which case carry out a functional check of the attenuators. If in the STANDARDIZE position check R707.

4.9.7 Recorder output

Suitable for use with 1 mA recorders.

With the receiver meter indicating f.s.d., the record output socket should provide 0.9 mA ±0.1 mA into a recorder of approximately 1000 Ω input impedance. If this specification is not met refer to Sect. 5.3.10.

4.9.8 Standardizing noise source

White noise is generated over the band 10 kHz to 13 MHz. Output level is -90 dBm per 3.1 kHz bandwidth (-95 dBm per 1 kHz bandwidth).

The noise source may be checked functionally by comparison with an external noise source of known power density, or by checking that the receiver can be set up to measure absolute noise as in Sect. 2.8. If a fault is suspected, see Sect. 5.3.8.

4.9.9 Local oscillator

Test equipment : item k.

The output level from each local oscillator board is between 0.3 V and 0.7 V e.m.f. depending on frequency. Source impedance is typically 1.5 kΩ in parallel with 75 pF.

When the local oscillator boards are fitted to the receiver, their output levels can be monitored by connecting the voltmeter to the L.O. socket (on the receiver front panel) for FREQUENCY SELECTOR positions 1 to 6. For further checks on the local oscillators see Sect. 5.3.12.

4.9.10 Frequency selector—position 7

Test equipment : items h and l.

External local oscillator input drive level is 0.6 V ±20% and input impedance is typically 6 kΩ in parallel with 60 pF. When used with a low noise external l.o., receiver sensitivity is typically -85 dBm.

Set the FREQUENCY SELECTOR to position 7 and connect the source signal (from h) to the external L.O. socket. Set the frequency within the range 12 kHz to 13 MHz and the level to approximately 600 mV r.m.s.

Set the N.P.R./NOISE INPUT attenuators to indicate 6 dB (actual attenuation 85 dB) ensuring that red spot on coarse attenuator knob corresponds with red line on skirt. Connect a signal, level 0 dBm, from l to the INPUT socket of the receiver. It should be possible to adjust the frequency to produce a peak on the meter at approximately ±500 Hz away from the external local oscillator frequency. The SET REFERENCE control can be used to obtain a satisfactory deflection above the basic noise level provided the f.m. noise of the l.o. source is low.

Chapter 5

Calibration and fault finding

5.1 INTRODUCTION

This chapter is intended to help users to fault-find, carry out internal checks, make minor adjustments and realign circuits; use in conjunction with the circuit diagrams at the rear of this manual.

CAUTION

See Sect. 4.1 for precautions in handling semiconductors and Sect. 4.9 for advice on quoted performance limits.

In case of any difficulty, please write or phone the Marconi Instruments Service Division (see address on back cover) or nearest representative, quoting the type and serial number on the data plate at the rear of the instrument. If the instrument is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

5.2 VOLTAGES

The voltages given on the circuit diagrams are those which may be expected on a typical OA 2090B at a mains input of 230 V, using a 20 kΩ/V meter, and are d.c., relative to chassis, unless otherwise indicated.

5.3 REALIGNMENT

Test equipment required for the procedures in this Section is listed in Sect. 4.7.

NOISE GENERATOR TF 2091B

5.3.1 Power supply

Preset controls: RV100, RV101, RV102.

Test equipment : items b and m.

Check the 54 V line. At 230 V a.c. mains input it should be 54 V ±1% and at 200 V and 250 V a.c. inputs it should be within ±300 mV of that measured at 230 V a.c. If necessary, set RV101 for 54 V and adjust RV100 for smallest variation of the 54 V line as the mains voltage is varied, by means of the Variac, between 190 and 260 V (or 95 and 130 V). Repeat adjustments of RV101 and RV100 as necessary.

Check the 25 V line. It should be within ±400 mV; adjust RV102 if necessary then recheck the 54 V line. Check that the 100 V line is between 96 V and 102 V.

5.3.2 Noise source

Preset controls : RV200, RV201, C207

Test equipment : items a, d and f

RV200 sets the current through the noise diode. The required bias current depends upon the particular noise diode and will be within the limits 300 μA to 2 mA. If the diode is operated with any other bias current it will not produce white noise. For this reason, unless it is quite certain that the instrument is faulty in this respect, no adjustment should be made to this control.

As a rough guide, the noise can be viewed on an oscilloscope - see Sect. 4.8.2.

Accurate measurements and setting up require a selective level meter with 75 Ω input impedance, a calibrated bandwidth between 2 kHz and 4 kHz, and a meter time constant approximately 1 second. Connect the level meter to PL200. The output noise power density measured at 100 kHz should be -90 dBm per 3.1 kHz (-95 dBm/kHz), and the variation of power density between 10 kHz and 13 MHz should not exceed 0.5 dB. Only if the noise power density at 100 kHz differs from nominal by more than 0.5 dB should RV200 be minimally adjusted to give a minimum power density. RV201 may then be adjusted to obtain the nominal power density and C207 to obtain a flat frequency characteristic.

5.3.3 Low level amplifier

Preset controls : RV300, RV301, C302, C306

Test equipment : items c, d and e

Disconnect the coaxial leads connecting the low level amplifier to the noise source and the high-pass filter. Connect the test equipment as in Fig. 5.1, feeding the output from the attenuator into SKT300, and taking the output from SKT301 to the output probe of the sweep generator. A 75 Ω impedance match must be preserved at both the input and output sockets.

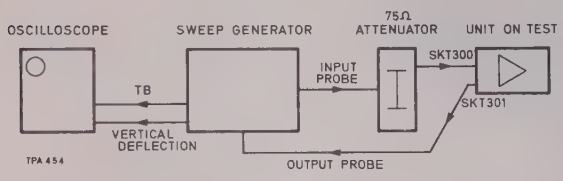


Fig. 5.1 Frequency response testing

Insert 50 dB in the external attenuator and adjust the sweep generator output to give an input of approximately 1 V to the attenuator. Set the sweep width to 13 MHz and check the flatness of the frequency response with the cover on. If the response is grossly non-flat, this indicates either a faulty component or a preset that has become misaligned.

Reduce the sweep width to minimum and check that the gain is 50 dB ±0.2 dB at 100 kHz. If necessary, remove the cover and adjust RV300 and RV301 to give zero differential deflection. Increase the sweep width again and adjust C302 and C306 to give the flattest possible response when the cover is on. The response should be flat to better than 0.1 dB between 100 kHz and 13 MHz; better than 0.1 dB from 100 kHz to 20 kHz and better than 0.3 dB from 20 kHz to 10 kHz.

5.3.4 High level amplifier

Preset controls : C407, R432

Test equipment : items d, e, h and k

With the a.l.c. circuit inhibited, i.e. with pins 511 and 513 on the power monitor unit shorted together, the gain of the high level amplifier measured between PL400 and SKT400 should exceed 33 dB at 100 kHz.

This can be measured by feeding a 100 kHz signal, at a level less than 100 mV, to the input of the first band-limiting filter FL3 and using a voltmeter to monitor the signal level at the OUTPUT socket terminated in 75 Ω. All filters should be switched out, pins 511 and 513 linked, NOISE switched ON (to maintain the +25 V supply to the high level amplifier) and the OUTPUT ATTENUATORS set to ADD 20 dB (actual signal attenuation 0 dB).

The peak factor can be checked by increasing the level of the 100 kHz input and displaying the signal at the OUTPUT (terminated in 75 Ω) on an oscilloscope. Limiting of the peaks should not occur until the output exceeds 18 V peak-to-peak.

The frequency response of this unit alone cannot be checked easily without specialized test fixtures. However, its response can be assumed to be correct if the overall frequency characteristic of the generator is within specification - see Sect. 4.8.2. If the characteristics of the Noise Source TM 9505 and Low Level Amplifier TM 7638 are within specification the preset control, C407, in the High Level Amplifier 46714-021 can be adjusted to bring the overall characteristic within specification.

The a.l.c. may be seen to be functioning correctly when the full range of the NOISE LEVEL control produces a meter deflection covering the calibrated portion of the scale (subject to available noise power density). Preset control R432 can be used to adjust the coverage of the NOISE LEVEL control.

5.3.5 Output power monitor

Preset controls : R521, R522, C502, C506, C507

Test equipment : items g, h and n

The detector of the power monitor is average reading calibrated in r.m.s. for white noise. Under zero signal input conditions, i.e. with the noise OFF, a meter indication of zero should be observed. If necessary the zero balance control R521 may be adjusted to achieve this.

CAUTION

When the generator a.l.c. is in operation, the standardized power monitor should be disconnected from the generator output whenever adjustment is made to the generator or filter switches since high transient levels may overload the power meter.

With the output of the generator connected directly to the standardized power meter, the accuracy of the monitor for an indicated output of 0 dBm may be obtained with the band-limiting filters fitted. R522 should be adjusted so that the monitor accuracy is within specification on all base bandwidths. Only if the specification cannot be met on all the base bandwidths is it necessary to check the frequency response.

The basic method of checking the frequency characteristic is to feed a sine wave from a 75 Ω signal source to the power monitor unit via the high level amplifier unit, set the OUTPUT ATTENUATORS to 0 dB and monitor the level at the OUTPUT socket using a standardized power meter. By selecting frequencies in the range 10 kHz to 13 MHz the response can be measured. Repeat for the ADD 10 dB and ADD 20 dB ranges by interposing a 10 dB and a 20 dB pad respectively between the generator output and the standardized power meter. C502, C506 and C507 can be adjusted for the ranges 0 dB, ADD 10 dB and ADD 20 dB respectively, and a typical response of 0.3 dB is to be expected.

Points to note are:

a) R522 may be adjusted to give any convenient meter indication during response measurement. At completion it should be set as above.

b) A.L.C. must be inhibited by shorting pins 511 and 513 together.

c) Cover of power monitor unit must be on during response measurement.

d) +5 dBm and +15 dBm ranges cannot be independently adjusted.

e) All presets are interactive so that a method of successive approximation has to be employed.

5.3.6 Attenuators 45 dB and 11 dB

The generator has a 45 dB coarse attenuator (TM 9515) and an 11 dB fine attenuator (TM 9516). Since the signal to the meter is +5 dBm when the meter reads 0 dBm, the coarse attenuation is actually 45 dB in the SUBTRACT 40 dB position - see Fig. 7.7. In the last three ADD positions the signal to the meter is attenuated but not the generator output. Characteristic impedance is 75 Ω.

Functional checks can be carried out - see Sect. 4.9.2 - on the attenuators, but, if a fault is suspected, report it to the Service Division.

NOISE RECEIVER TF 2092B

5.3.7 Power supply

Preset controls : RV100, RV101

Test equipment : items m and b

Check the 25 V line. At 230 V a.c. mains input it should be 25 V ±1% and with 190 V to 260 V a.c. mains, the variation should not exceed ±100 mV. If necessary, set RV101 for 25 V and adjust RV100 for smallest variation of the 25 V line as the mains voltage is varied, by means of a Variac, between 190 V and 260 V (or 95 V and 130 V). Repeat adjustments for best results.

Check the 100 V line which should be 100 V ±5% with 230 V a.c. mains.

5.3.8 Standardizing noise source

Preset controls : RV700

Test equipment : items a and f.

RV700 sets the current through the noise diode. The required bias current depends upon the particular noise diode and should be within the limits 300 μA to 2 mA. If the diode is operated with any other bias current it will not produce white noise. Therefore, unless it is quite certain that the instrument is faulty in this respect, no adjustment should be made to this preset control.

Performance may be checked using a level meter as specified in 5.3.2. Select STANDARDIZE and connect the level meter to PL700. The output noise power density measured at 100 kHz should be -90 dBm per 3.1 kHz (-95 dBm/kHz), and the variation of power density between 10 kHz and 13 MHz should not exceed 0.5 dB. Only if the noise power density at 100 kHz differs from nominal by more than 0.5 dB should RV700 be minimally adjusted to give a minimum power density. If necessary R705 and C707 may be selected to obtain the nominal power density and a flat frequency characteristic.

5.3.9 Mixer unit

Preset controls : R304, C302, R313

Test equipment : items h and k

The mixer unit consists of a wideband amplifier stage with a voltage gain of 22 dB followed by a mixer stage with a voltage conversion gain of approximately 10 dB. However, it is not possible to measure directly the gain of the mixer unit because of the high level of local oscillator signal at the mixer output socket SKT301. The gain is therefore measured for:

a) the wide band amplifier and
b) the mixer stage with part of the l.f. amplifier.

To check the wide band amplifier, connect the signal generator to SKT300 and the voltmeter to tag 307 of the mixer board. With the generator set to 100 kHz and 10 mV, the voltage at pin 307 should be 126 mV. If any components have been replaced, the gain can be reset by adjusting R304. The amplifier frequency response should be flat to better than 1 dB from 10 kHz to 13 MHz when the mixer cover is fitted. C302 is the preset but should only be adjusted with a specialized test fixture.

To check the mixer, remove the link across tags 307 and 308, switch to the lowest frequency local oscillator and connect the signal generator to tag 308, the input to the mixer. Set the signal generator frequency to about 500 Hz different from the local oscillator and set the level to 1 mV. Monitor the voltage at the top of RV1 (SET REFERENCE control) with this control turned fully counter-clockwise. Between the mixer output socket SKT301 and this point, the l.f. amplifier has a gain of approximately 40 dB, thus the gain measured between tag 308 and RV1 should be 50 dB. If necessary, adjust R313 on the mixer board for maximum output on the voltmeter which should read 320 mV approximately.

5.3.10 L.F. amplifier

Test equipment : item l

An input applied at PL400 of approximately 48 μV r.m.s. at a frequency of 500 Hz should give full-scale deflection on the meter with the SET REFERENCE control and all EQUALIZE RANGE SENSITIVITY potentiometers turned fully clockwise. 3 dB cut-off frequencies occur at approximately 40 Hz and 1100 Hz. The roll-off above 1.1 kHz is at the rate of 24 dB per octave and is determined by the first and second stages which are coupled stages of a low-pass active filter.

The final stage is a full-wave detector with overall current feedback. The detector diodes are MR400 and MR401. A chain of diodes, MR402, MR403 and MR404 are used to provide protection of the meter from transient overloads during switching.

MR405 and MR406 act as d.c. restorers and detect the output for application to an external recorder. Isolation from the main circuit is provided by the emitter follower VT409.

There are no preset controls on this unit.

The EQUALIZE RANGE SENSITIVITY potentiometers (on the front panel) enable the l.f. amplifier gain to be varied over a range of 10 dB.

5.3.11 Attenuators 80 dB and 11 dB

The receiver has an 80 dB coarse attenuator (TM 9510) and an 11 dB fine attenuator (TM 9511). When the n.p.r. is set to read 91 dB actual attenuation is zero. Characteristic impedance is 75 Ω.

Suspected faults should be reported to the Service Division.

5.3.12 Local oscillator

Test equipment : items j and k

The performance of each oscillator may be checked at the L.O. external socket by switching to each oscillator in turn from position 1 to 6.

The frequency may be checked by connecting the frequency counter to the external socket. For crystal oscillators (54493 series) the frequencies should be typically 0.02% of the nominal value. L-C oscillators (TM 7793/4/5 series) should be typically within 0.5% of nominal value.

The output voltage level may be checked using the voltmeter connected to the external L.O. socket. For the 54493 series the level should be approximately 700 mV r.m.s. for the lowest frequency oscillator and should decrease to not less than 300 mV r.m.s. for the highest frequency oscillator.

Suspected faults on any oscillator should be reported to the Service Division.

5.3.13 Filters

The filters are described in Sect. 3.3 and specified in the Data Summary Sect. 1.2. Their characteristics can be checked using a selective level measuring set; but filters should not be aligned without special test fixtures. If a fault is suspected, it should be reported to the Service Division.

5.4 FAULT FINDING

Back-to-back test

This test - see Sect. 4.8.1 - is an overall test of noise generator, noise receiver, band-stop and band-pass filters, and oscillators, and can be used for preliminary fault location.

Faults

The following tables list some of the possible fault conditions which may be encountered and indicate an appropriate procedure to locate the fault. The tables should be used in conjunction with the circuit diagrams at the rear of the manual and with the tests detailed in Sect. 5.3.

Table 5.1 Noise generator

Symptom	Possible fault area	Method of fault location
No pilot light.	Mains input.	Check mains connection.
	Blown mains fuses.	Check for short circuit.
Zero output and zero meter reading.	NOISE ON/OFF switch.	Check switch position.
	Filter switch mechanism.	Operate each filter switch in turn.
	Internal connections.	Examine.
	Blown h.t. fuses.	Check for short circuit.
	Power supply.	Check voltages on sub-units (Fig. 7.1).
	Sub-units namely:	
	High level output stage, High level amplifier, Low level amplifier, Noise source.	Check output at SKT400 with PL400 plugged into SKT301. If no output check that sub-units function.
Meter indication but zero output.	Output attenuators.	Check functionally (Fig. 7.7 and 7.8).
Meter indication too high.	Low-pass filters.	Check cut-off frequency. For cut-off frequency above 8 MHz, check that pass band insertion loss exceeds 4 dB.
	Power monitor, a.l.c. cable or a.l.c. circuit (in high level amplifier).	Check voltage between pins 406 and 407 of high level amplifier. If zero voltage. fault in cable or power monitor. If >10 mV, fault in a.l.c. circuit.
Poor 'back-to-back' n.p.r.	Loading level.	Check 0 dBm output level.
	Band-stop filter.	Check filter characteristics.

Table 5.2 Noise receiver

Symptom	Possible fault area	Method of fault location
No Pilot light.	Blown mains fuses.	Check for short circuit.
Zero meter reading.	Blown fuse.	Check for short circuit.
	Power supply.	Check for voltages on sub-units (Fig. 7.9).
	Meter.	Check for open circuit.
	L. F. connections.	Check continuity from SKT607 to SET REFERENCE control.
	L. F. amplifier.	Functionally check.
Lack of sensitivity on all ranges.	OPERATE/STANDARDIZE switch.	Check switch for required operation.
	EQUALIZE RANGE SENSITIVITY presets.	Turn fully clockwise.
	Attenuator switch mechanism.	Switch through all attenuator positions.
	Internal connections.	Examine leads to band-pass filters. Check that frequencies of local oscillators and band-pass filters correspond.
	Mixer and l. f. amplifier units.	Functionally check.
Lack of sensitivity on one range only.	EQUALIZE RANGE SENSITIVITY presets.	Turn fully clockwise.
	Local oscillator.	Check frequency and level at L. O. socket. A high standing reading indicates oscillator f. m. noise.
	Internal connections.	Examine leads to band-pass filter. Check that frequency of local oscillator and band-pass filter correspond.
	FREQUENCY SELECTOR switch (positions 1 to 6).	Check with oscillator and filter in another position.
	Band-pass filter.	Check pass band insertion loss - see Sect. 3.3.
Poor 'back-to-back' n. p. r.	Attenuators.	Functionally check.
	Local oscillator.	Check frequency at L. O. socket.
	Band-pass filter.	Check characteristics.

Chapter 6

Replaceable parts

Introduction

This chapter lists replaceable parts in alphabetical order of their circuit references, with miscellaneous parts at the end of the list. The following abbreviations and symbols are used:

C	:	capacitor
Carb	:	carbon
Cer	:	ceramic
D	:	semiconductor diode
Elec	:	electrolytic
FB	:	ferrite bead
FS	:	fuse
JK	:	jack
L	:	inductor
Log	:	logarithmic law
M	:	meter
Met ox	:	metal oxide
MR	:	semiconductor diode
PL	:	plug
Plas	:	plastic
PLP	:	pilot lamp
R	:	resistor and variable resistor
RV	:	variable resistor
S	:	switch
SKT	:	socket
T	:	transformer
TE	:	total excursion
TFC	:	thin film circuit
TH	:	thermistor
TP	:	terminal
TR	:	transistor
Var	:	variable or preset
VT	:	transistor
W	:	watts at 70 °C
W*	:	watts at 55 °C
WW	:	wirewound
X	:	ferrite bead
†	:	value selected during test; nominal value listed

Ordering

Orders for replacement parts should be sent to our Service Division at the address on the back cover. Specify the following information for each part required:

1. Type and serial number of instrument.
2. Circuit reference.
3. Description.
4. M.I. code number.

A part may differ from the part listed owing to supply difficulties or design improvements. Always use as a replacement the same type and value as found in the instrument.

If a part is not listed state its function, location and description when ordering.

Noise generator - Fig. 7.1 to 7.9

Circuit reference	*Description*	*M.I. code*
C1	Elec 2500µF +50-20% 100V	26427-137
C2	Plas 0.1µF ±20% 400V	26511-354
C100	Elec 47µF +50-20% 160V	26415-812
C101	Elec 100µF +50-20% 100V	26415-816
C102	Elec 100µF +100-20% 25V	26415-813
C103	Elec 100µF +100-20% 63V	26415-815
C104	Elec 100µF +100-20% 63V	26415-815
C105	Elec 100µF +100-20% 63V	26415-815
C106	Elec 10µF +100-20% 63V	26415-802
C200	Plas 0.1µF ±10% 250V	26582-208
C201	Paper 0.25µF ±10% 150V	26174-175
C202	Plas 0.1µF ±10% 250V	26582-208
C203	Elec 25µF +100-20% 35V	26417-143
C204	Plas 1µF ±10% 125V	26511-383
C205	Elec 250µF +100-20% 6V	26417-162
C206 †	Plas 270pF ±2% 125V	26516-350
C207	Var 10-60pF	26847-267
C208	Paper 0.5µF ±10% 150V	26174-179
C300	Plas 0.1µF ±10% 250V	26582-208
C301	Plas 0.47µF ±10% 125V	26511-374
C302	Cer 3-40pF Trimmer	26848-215
C303	Elec 25µF +100-20% 35V	26417-143
C304	Plas 0.1µF ±10% 250V	26582-208
C305	Paper 0.25µF ±10% 150V	26174-175
C306	Cer 3-40pF Trimmer	26848-215
C307	Elec 25µF +100-20% 35V	26417-143
C308	Plas 0.1µF ±10% 250V	26582-208

CASES FOR 2092 OR 2091 —, A OR B
PART # [illegible]83-A150 ORDER FROM NORTHVALE, N.J.

Circuit reference	Description	M.I. code
C309	Plas 1μF ±10% 125V	26511-383
C400	Plas 0.22μF ±10% 63V	26582-406
C401	Cer 0.1μF +50-25% 30V	26383-031
C402	Elec 1μF ±20% 35V	26486-513
C403	Plas 0.1μF ±10% 250V	26582-211
C404	Elec 22μF ±20% 15V	26486-583
C405	Plas 0.1μF +50-25% 30V	26383-031
C406	Plas 22pF ±2pF 125V	26516-088
C407	3-16pF Trimmer	26842-101
C408	Elec 22μF +100-20% 63V	26415-806
C409	Plas 0.22μF ±10% 63V	26582-406
C410	Elec 4.7μF +100-20% 63V	26415-801
C411	Plas 0.1μF ±10% 250V	26582-211
C412	Plas 1μF ±10% 250V	26582-414
C413	Elec 1μF ±20% 35V	26486-513
C414	Elec 10μF +100-20% 63V	26415-802
C418	Elec 22μF +100-20% 25V	26415-805
C419	Plas 10pF ±1pF 125V	26516-009
C420	Cer 0.01μF +80-20% 100V	26383-055
C500	Cer 0.1μF +50-25% 30V	26383-031
C501	Cer 0.1μF +50-25% 30V	26383-031
C502	Var 0.6pF-5pF	26845-151
C503	Plas 0.1μF ±10% 250V	26582-208
C504	Elec 100μF +100-20% 25V	26423-327
C505	Plas 0.33μF ±10% 125V	26511-368
C506	Var 4pF-20pF 250V	26847-244
C507	Var 0.6pF-5pF	26845-151
C509	Cer 0.1μF +50-25% 30V	26383-031
C510	Elec 10μF +100-20% 63V	26423-215
C511	Cer 0.1μF +50-25% 30V	26383-031
C512	Plas 1μF ±10% 125V	26511-383
C513	Plas 0.1μF ±10% 250V	26582-208
C514	Plas 0.1μF ±10% 250V	26582-208
C515	Cer 0.1μF +50-25% 30V	26383-031
C516	Cer 0.1μF +50-25% 30V	26383-031
C517	Elec 10μF +100-20% 63V	26423-215
C518	Cer 0.1μF +50-25% 30V	26383-031
C519	Plas 0.1μF ±10% 250V	26582-208
D400	16V Zener	28372-473
D401	13V Zener	28372-213
D500	1N914	28336-676
FS1	500mA, 230V	23411-005
	1A, 110V	23411-006
FS2	500mA, 230V	23411-005
	1A, 110V	23411-001
FS3	500mA, quick acting	23411-005
FS4	50 mA, quick acting	23411-001
IC400	μA741C	28461-331
L400	Inductor	44235-208
M1	1000Ω, 100μA	44572-227
MR100	1N540	28357-048
MR101	1N540	28357-048
MR102	DDO 58	28358-817
MR103	ZB 15.0 ±5%	28372-306
MR104	ZB 15.0 ±5%	28372-306
MR105	ZB 15.0 ±5%	28372-306
MR106	ZB 5.6 ±5%	28371-436
MR107	ZB 5.6 ±5%	28371-436
MR108	ZB 5.6 ±5%	28371-436
MR200	Z1M (special)	44521-019
PL1	3 pin, 6A	23423-159
PL2	75Ω BNC (free)	23443-335
PL3	75Ω BNC (free)	23443-335
PL4	75Ω BNC (free)	23443-335
PL5	75Ω BNC (free)	23443-335

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
PL200	75Ω BNC (free)	23443-335
PL400	75Ω BNC (free)	23443-335
PL500	75Ω BNC (free)	23443-335
PL501	75Ω BNC (elbow)	23443-343
PLP1	Neon 80-100V	23733-151
PLP2	Bulb 14V	23735-458
R1	Carb 33kΩ ±10% ½W*	24342-122
R2	Carb 33kΩ ±10% ½W*	24342-122
R3	Met ox 5.6kΩ ±5% 1W	24585-144
R4	Carb 330Ω ±2% ½W	24573-061
R100	WW 3.3Ω ±5% 2½W	25133-008
R101	Carb 8.2kΩ ±10% ½W*	24342-108
R102	Met ox 1.8kΩ ±7% TE 3/8W*	24552-086
R103	Met ox 22kΩ ±7% TE 3/8W*	24552-118
R105	Met ox 3.3kΩ ±7% TE 3/8W*	24552-094
R106	Carb 33kΩ ±10% ½W*	24342-122
R107	WW 100Ω ±5% 2½W	25123-050
R108	Carb 10kΩ ±10% ½W*	24342-110
R109	Met ox 2.4kΩ ±7% TE 3/8W*	24552-089
R110	Met ox 6.8kΩ ±7% TE 3/8W*	24552-106
R111	Met ox 220Ω ±2% .W	24573-057
R112	Met ox 39Ω ±5% ½W	24573-039
R113	WW 360Ω ±5% 3W	25125-064
R200†	Met ox 33kΩ ±7% TE 3/8W*	24552-122
R201	Met ox 6.8kΩ ±7% TE 3/8W*	24552-106
R202	Met ox 6.8kΩ ±7% TE 3/8W*	24552-106
R203†	Met ox 39Ω ±7% TE 3/8W*	24552-035
R204	Met ox 470Ω ±7% TE 3/8W*	24552-069
R205	Met ox 200Ω ±7% TE 3/8W*	24552-057
R206	Met ox 100Ω ±7% TE 3/8W*	24552-050
R207	Met ox 4.7kΩ ±7% TE 3/8W*	24552-100
R300	Met ox 75Ω ±7% TE 3/8W*	24552-044
R301	Met ox 2.2kΩ ±7% TE 3/8W*	24552-088
R302	Carb 3.3kΩ ±10% ½W*	24342-094
R303	Met ox 47Ω ±7% TE 3/8W*	24552-037
R304	Met ox 1.2kΩ ±7% TE 3/8W*	24552-082
R305	Carb 47kΩ ±10% ½W*	24342-126
R306	Met ox 220Ω ±7% TE 3/8W*	24552-058
R307	Carb 1kΩ ±10% ½W*	24342-080
R308	Met ox 1kΩ ±7% TE 3/8W*	24552-080
R309	Carb 2.2kΩ ±10% ½W*	24342-088
R310	Met ox 56Ω ±7% TE 3/8W*	24552-040
R311	Met ox 1.5kΩ ±7% TE 3/8W*	24552-084
R312	Carb 47kΩ ±10% ½W*	24342-126
R313	Carb 1kΩ ±10% ½W*	24342-080
R314	Carb 1kΩ ±10% ½W*	24342-080
R315	Met ox 560Ω ±7% TE 3/8W*	24552-072
R316	Met ox 68Ω ±7% TE 3/8W*	24552-043
R400	Met film 76.5Ω ±1% ¼W	24636-356
R401	Met ox 30kΩ ±2% ½W	24573-108
R402	Met ox 3.9kΩ ±2% ½W	24573-087
R403	Met ox 100Ω ±2% ½W	24573-049
R404	Met ox 240Ω ±2% ½W	24573-058
R405	Met ox 750Ω ±2% ½W	24573-070
R406	Met ox 2.7Ω ±5% ½W	24552-006
R407	Met ox 2.7kΩ ±2% ½W	24573-083
R408	Met ox 120Ω ±2% ½W	24573-051
R409	Met ox 2.4kΩ ±2% ½W	24573-082
R410	Met ox 68kΩ ±2% ½W	24573-117
R411	Met ox 560Ω ±2% ½W	24573-067
R412	Met film 820Ω ±2% ½W	24573-071
R413	Met film 20kΩ ±2% ½W	24573-104
R414	Met film 3.9kΩ ±2% ½W	24573-087
R415	Met ox 2.7kΩ ±2% ½W	24573-083
R416	Met film 240Ω ±2% ½W	24573-058

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R417	Met ox 510Ω ±7% TE 3/8W*	24573-066
R418	Met ox 1.6kΩ ±2% ½W	24573-078
R419	Met ox 301Ω ±1% ½W	24527-262
R420	Met film 270Ω ±1% 1W	24666-704
R424	Met film 270Ω ±1% 1W	24666-704
R425	Met ox 2kΩ ±2% ½W	24573-080
R426	Met ox 2kΩ ±2% ½W	24573-080
R427	Met ox 1MΩ ±2% ½W	24573-145
R428	Met ox 1MΩ ±2% ½W	24573-145
R429	Met ox 3.9kΩ ±2% ½W	24573-087
R430	Met ox 22kΩ ±2% ½W	24773-305
R431	Met ox 3.9kΩ ±2% ½W	24573-087
R432	Var WW 10kΩ	25811-025
R433	Met ox 11kΩ ±2% ½W	24573-098
R434	Met ox 22kΩ ±2% ½W	24773-305
R435	Var Cer 1kΩ ±10% 1W	25723-501
R436	Met ox 560Ω ±2% ½W	24573-067
R437	Met ox 3.6kΩ ±2% ½W	24573-086
R438	Met ox 1.2kΩ ±2% ½W	24573-075
R439	Met ox 7.5kΩ ±2% ½W	24573-094
R440	Met ox 47kΩ ±2% ½W	24773-313
R441	Met ox 47kΩ ±2% ½W	24773-313
R500	Met ox 27kΩ ±2% ½W	24578-107
R501	Met ox 24kΩ ±2% ½W	24573-106
R502	Met film 6.51kΩ ±1% ¼W	24637-311
R503	Met film 6.2kΩ ±1% ¼W	24637-303
R504	Met film 3.9kΩ ±1% ¼W	24637-209
R505	Met ox 10kΩ ±2% ½W	24573-097
R506	Met ox 1kΩ ±2% ½W	24573-073
R507	Met ox 910Ω ±2% ½W	24573-072
R508	Met film 629Ω ±0.25% ¼W	24633-303
R509	Met film 3.20kΩ ±0.25% ¼W	24633-401
R510	Met film 535Ω ±0.25% ¼W	24633-301
R511	Met film 1.59kΩ ±0.25% ¼W	24633-401
R512	Met film 538Ω ±0.25% ¼W	24633-302
R513	Met film 695Ω ±0.25% ¼W	24633-304
R514	Met ox 2.2kΩ ±2% ½W	24573-081
R515	Met film 36kΩ ±1% ¼W	24637-561
R516	Met film 12kΩ ±1% ¼W	24637-513
R517	Met ox 220Ω ±2% ½W	24573-057
R518	Met ox 1kΩ ±2% ½W	24573-073
R519	Met ox 100Ω ±2% ½W	24573-049
R520	Met ox 100Ω ±2% ½W	24573-049
R521	Var WW 4.7kΩ	25811-023
R522	Var WW 1kΩ	25811-019
R523	Met ox 510kΩ ±2% ½W	24573-138
RV100	Carb 100kΩ ±20% ¼W*	25611-038
RV101	Carb 1kΩ ±20% ¼W*	25611-072
RV102	Carb 100Ω ±20% ¼W*	25611-002
RV200	Carb 47kΩ ±20% ¼W	25611-082
RV201	Carb 100Ω ±20% ¼W	25611-066
RV300	Carb 1kΩ ±20% ¼W*	25611-114
RV301	Carb 1kΩ ±20% ¼W*	25611-114
SA	ON/OFF	44334-003
SB	Mains tapping	23467-119
SC	Meter sensitivity	44325-701
SD	NOISE ON/OFF	23462-262

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
TR400	BC 109	28452-777
TR401	2N 2369	28452-197
TR402	2N 2369	28452-197
TR403	BSX 20	28452-207
TR404	BSX 20	28452-207
TR405	MM 1613	28454-776
TR407	BF 244B	28459-011
TR408	2N 4859A	28459-014
TR409	2N 2369	28452-197
TR410	BF 244B	28459-011
TR500	BSX 20	28452-197
TR501	BSX 20	28452-207
TR502	BSX 20	28452-197
SKT1	75Ω	23443-508
SKT2		23443-380
SKT300	75Ω BNC	23443-498
SKT301	75Ω BNC	23443-454
SKT400	75Ω BNC	23443-454
T1	Mains input 230V & 110V	43443-005
TFC500	Thin film circuit	44381-001
TH400	100kΩ	25683-335

Circuit reference	Description	M.I. code
VT1	2N 1531 only	28426-856
VT100	ACY 17	28426-497
VT101	2S 305	28436-318
VT200	BC 109B	28452-789
VT300	2N 2369	44522-020
VT301	2N 2369	44522-020
VT302	2N 2369	44522-020
VT303	2N 2369	44522-020
VT304	2N 2219	28453-847
X300	FX 1115	23635-833
X301	FX 1115	23635-833
Lead assembly (PL3 to PL4)		43125-036
Control knobs		
80 dB attenuator		41145-240
40 dB attenuator		41145-243
11 dB attenuator		41145-236
Set reference		41142-210
Standardize/operate		41145-203
Frequency selector		41145-206

For symbols and abbreviations see introduction to this chapter

Noise receiver - Fig. 7.9 to 7.11, 7.14 and 7.15

Circuit reference	Description	M.I. code
C1	Elec 1000μF +50-20% 50V	26427-332
C100	Elec 100μF +100-20% 50V	26417-160
C101	Elec 100μF +100-20% 25V	26417-158
C102	Elec 100μF +100-20% 25V	26417-158
C103	Elec 32μF +50-20% 300V	26417-485
C104	Elec 1μF +100-20% 50V	26414-106
C300	Plas 0.22μF ±10% 63V	26582-406
C301 †	Plas 68pF ±2pF 125V	26516-201
C302	Var Cer 4-20pF	26847-243
C303	Cer 0.1μF +50-25% 30V	26383-031
C304	Elec 22μF +100-20% 40V	26423-222
C305	Elec 10μF +100-20% 63V	26423-215
C306	Cer 0.1μF +50-25% 30V	26383-031
C307	Plas 0.33μF ±10% 63V	26582-408
C308	Plas 0.33μF ±10% 63V	26582-408
C309	Cer 0.1μF +50-25% 30V	26383-031
C310	Elec 22μF +100-20% 40V	26423-222
C311	Elec 100μF +100-20% 10V	26423-204
C312	Cer 0.1μF +50-25% 30V	26383-031
C313	Cer 0.01μF +80-20% 100V	26383-055
C314	Cer 0.1μF +50-25% 30V	26383-031
C315	Cer 0.1μF +50-25% 30V	26383-031
C316	Cer 0.1μF +50-25% 30V	26383-031
C317	Elec 100μF +100-20% 25V	26423-243
C318	Cer 0.1μF +50-25% 30V	26383-031
C320	Cer 0.1μF +50-25% 30V	26383-031
C400	Elec 10μF +100-20% 6V	26414-120
C401	Plas 0.0159μF 63V	26538-485
C402	Plas 0.0136μF 63V	26538-484
C403	Elec 25μF +100-20% 25V	26423-311
C404	Elec 1μF +50-20% 50V	26414-106
C405	Plas 0.0377μF 63V	26538-494
C406	Plas 0.00554μF 63V	26538-476
C407	Elec 25μF +100-20% 25V	26423-311
C408	Elec 25μF +100-20% 6V	26412-243
C409	Elec 5μF +100-20% 15V	26414-113
C410	Cer 0.01μF +80-20% 100V	26383-055
C411	Elec 400μF +100-20% 6V	26423-341
C412	Elec 500μF +100-20% 12V	26417-172
C413	Elec 10μF +100-20% 35V	26414-121
C414	Elec 10μF +100-20% 35V	26414-121
C415	Elec 12μF +100-20% 50V	26423-309
C416	Elec 25μF +100-20% 25V	26423-311
C417	Elec 250μF +100-20% 6V	26417-162
C418	Cer 0.1μF +50-25% 30V	26383-031
C419	Elec 25μF +100-20% 25V	26423-311
C600	Elec 1μF +100-20% 50V	26414-106
C601	Plas 0.1μF ±10% 250V	26582-208
C602	Cer 0.1μF +50-25% 30V	26383-031

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C700	Plas 0.1μF ±10% 250V	26582-208
C701	Paper 0.25μF ±10% 150V	26174-175
C702	Plas 0.1μF ±10% 250V	26582-208
C703	Plas 0.1μF ±10% 250V	26582-208
C704	Elec 25μF +100-20% 35V	26417-143
C705	Plas 1μF ±10% 125V	26511-383
C706	Paper 0.5μF ±10% 150V	26174-179
C707†	Plas 270pF ±2% 500V	26516-352
C708	Elec 250μF +100-20% 6V	26417-162
C709	Plas 0.01μF ±10% 200V	26174-145
C710	Plas 10pF ±1pF 125V	26516-009
C711	Cer Var 3 to 10pF	26847-212
FB1	FX 1115	23635-833
FB2	FX 1115	23635-833
FS1	100mA 230V	23411-002
FS2	100mA 230V	23411-002
FS3	250mA	23411-004
JKA	Panel jack (single leaf)	23421-607
L300	Coil 4.5μH	44221-013
L301	Coil	44261-009
M1	1000Ω, 100μA	44572-218
MR100	1N540	28357-048
MR101	1N540	28357-048
MR102	Zener 7.5V ±5%	28371-606
MR103	DDO 58	28358-817
MR104	Zener 20V ±5%	28372-786
MR105	Zener 20V ±5%	28372-786
MR106	Zener 20V ±5%	28372-786
MR107	Zener 20V ±5%	28372-786
MR108	Zener 20V ±5%	28372-786

Circuit reference	Description	M.I. code
MR400	HG 1005	28323-035
MR401	HG 1005	28323-035
MR402	1S44	28357-548
MR403	1S44	28357-548
MR404	1S44	28357-548
MR405	HG 1005	28323-035
MR406	HG 1005	28323-035
MR700	Z1M (selected)	44521-025
PL1	3 pin, 6A	23423-159
PL3	75Ω BNC	23443-335
PL4	75Ω BNC	23443-335
PL7	Min r.f.	23441-014
PL300	75Ω BNC	23443-335
PL400	75Ω BNC	23443-335
PL401	Min r.f.	23441-014
PL600	75Ω BNC	23443-335
PL601	75Ω BNC	23443-335
PL602	75Ω BNC	23443-335
PL603	75Ω BNC	23443-335
PL604	75Ω BNC	23443-335
PL605	75Ω BNC	23443-335
PL606	75Ω BNC	23443-335
PL607	75Ω BNC	23443-335
PL608	75Ω BNC	23443-335
PL609	75Ω BNC	23443-335
PL610	75Ω BNC	23443-335
PL611	75Ω BNC	23443-335
PL612	75Ω BNC	23443-335
PL613	75Ω BNC	23443-335
PL700	75Ω BNC	23443-313
PLP1	Neon 80-100V	23733-151

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R1	Carb 33kΩ ±10% ½W*	24342-122
R2	Carb 15kΩ ±10% ½W*	24342-114
R3	Met ox 100Ω ±7% 3/8W*	24552-050
R100	WW 3.3Ω ±10% 1½W	25133-008
R101	WW 100Ω ±5% 1½W	25123-050
R102	Carb 6.8kΩ ±10% ½W*	24342-106
R103	Carb 2.2kΩ ±10% ½W*	24342-088
R104	Carb 220Ω ±10% ½W*	24342-058
R105	Carb 3.9kΩ ±10% ½W*	24342-096
R106	Met ox 56kΩ ±7% TE 3/8W*	24552-129
R107	Carb 5.6kΩ ±10% ½W*	24342-103
R108	Met ox 1.5kΩ ±7% TE 3/8W*	24552-084
R109	Met ox 3.9kΩ ±7% TE 3/8W*	24552-096
R110	Met ox 15kΩ ±7% TE 3/8W*	24552-114
R300	Met ox 750Ω ±2% ½W	24573-070
R301	Met ox 220Ω ±2% ½W	24573-057
R302	Met ox 1MΩ ±2% ½W	24573-145
R303	Met ox 2.7kΩ ±2% ½W	24573-083
R304	Var Carb 1kΩ ±20% ¼W	25611-072
R305	Met ox 1.8kΩ ±2% ½W	24573-079
R306	Met ox 2.7kΩ ±2% ½W	24573-083
R307	Met ox 2.2kΩ ±2% ½W	24573-081
R308	Met ox 100Ω ±2% ½W	24573-049
R309	Met ox 47Ω ±2% ½W	24573-041
R310	Met ox 820Ω ±2% ½W	24573-071
R311	Met ox 7.5kΩ ±2% ½W	24573-094
R312	Met ox 47kΩ ±2% ½W	24573-113
R313	Var WW 2.2kΩ ±10% 1W	25811-021
R314	Met ox 2.2kΩ ±2% ½W	24573-081
R315	Met ox 75Ω ±2% ½W	24573-046
R316	Met ox 5.1kΩ ±2% ½W	24573-090
R317	Met ox 470Ω ±2% ½W	24573-065
R318	Met ox 1kΩ ±2% ½W	24573-073
R319	Met ox 2.2kΩ ±2% ½W	24573-081
R320	Met ox 680Ω ±2% ½W	24573-069
R321	Met ox 22kΩ ±2% ½W	24573-105
R322	Met ox 10kΩ ±2% ½W	24573-097
R323	Met ox 100Ω ±2% ½W	24573-049
R324	Met ox 1.6kΩ ±2% ½W	24573-078
R325	Met ox 150Ω ±2% ½W	24573-053
R400	Met ox 110kΩ ±7% TE 3/8W*	24552-136
R401	Met ox 12kΩ ±7% TE 3/8W*	24552-112
R402	Met film 10kΩ ±0.5% ¼W	24635-504
R403	Met film 10kΩ ±0.5% ¼W	24635-504
R404	Met film 464Ω ±0.2% ¼W	24633-264
R405	Met film 4.38kΩ ±0.2% ¼W	24633-461
R406	Met ox 4.7kΩ ±7% TE 3/8W*	24552-100
R407	Met film 317Ω ±0.2% ¼W	24633-262
R408	Met film 35Ω ±0.2% ¼W	24633-061
R409	Met ox 110kΩ ±7% TE 3/8W*	24552-136
R410	Met ox 12kΩ ±7% TE 3/8W*	24552-112
R411	Met film 10kΩ ±0.5% ¼W	24635-504
R412	Met film 10kΩ ±0.5% ¼W	24635-504
R413	Met film 464Ω ±0.2% ¼W	24633-264
R414	Met film 4.38kΩ ±0.2% ¼W	24633-461
R415	Met ox 4.7kΩ ±7% TE 3/8W*	24552-100
R416	Met film 317Ω ±0.2% ¼W	24633-262
R417	Met film 35Ω ±0.2% ¼W	24633-061
R418	Met ox 12kΩ ±7% TE 3/8W*	24552-112
R419	Met ox 33kΩ ±7% TE 3/8W*	24552-122
R420	Met ox 1.1kΩ ±7% TE 3/8W*	24552-081
R421	Met ox 22Ω ±2% ½W	24573-033
R422	Met ox 4.7kΩ ±7% TE 3/8W*	24552-100
R423	Met ox 33kΩ ±7% TE 3/8W*	24552-122
R424	Met ox 750Ω ±2% ½W	24573-070

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R425	Met ox 1kΩ ±7% TE 3/8W*	24552-080
R426	Met ox 470Ω ±7% TE 3/8W*	24552-069
R427	Met ox 68Ω ±7% TE 3/8W*	24552-043
R428	Met ox 1.1kΩ ±7% TE 3/8W*	24552-081
R429 †	Met ox 9.1kΩ ±7% TE 3/8W*	24552-109
R430	Met ox 3.3kΩ ±7% TE 3/8W*	24552-094
R431	Met ox 330Ω ±7% TE 3/8W*	24552-063
R432	Met ox 2.2kΩ ±7% TE 3/8W*	24552-088
R600	Met ox 1.8kΩ ±7% TE 3/8W*	24552-086
R601	Met ox 680Ω ±7% TE 3/8W*	24552-076
R602	Met ox 82Ω ±7% TE 3/8W*	24552-046
R603	Met ox 10kΩ 2% ½W	24573-097
R700 †	Met ox 33kΩ ±7% TE 3/8W*	24552-122
R701	Met ox 2kΩ ±7% TE 3/8W*	24552-087
R702	Met ox 6.8kΩ ±7% TE 3/8W*	24552-106
R703	Met ox 6.8kΩ ±7% TE 3/8W*	24552-106
R704	Met film 75Ω ±1% ¼W	24636-476
R705 †	Met ox 56Ω ±7% TE 3/8W*	24552-040
R706	Met ox 150Ω ±7% TE 3/8W*	24552-054
R707	Met film 75Ω ±1% ¼W	24636-476
RV1	WW 1kΩ ±10% 3W	25823-413
RV100	Carb 100kΩ ±20% ¼W	25611-038
RV101	Carb 470Ω ±20% ¼W	25611-010
RV600	Carb 2.2kΩ ±20% ¼W	25611-018
RV601	Carb 2.2kΩ ±20% ¼W	25611-018
RV602	Carb 2.2kΩ ±20% ¼W	25611-018
RV603	Carb 2.2kΩ ±20% ¼W	25611-018
RV604	Carb 2.2kΩ ±20% ¼W	25611-018
RV605	Carb 2.2kΩ ±20% ¼W	25611-018
RV700	Carb 47kΩ ±20% ¼W	25611-034

Circuit reference	Description	M.I. code
SA	ON/OFF switch	44334-003
SB	Mains tapping	23467-119
SC	Frequency selector	44325-302
SD	Operate/standardize	44321-704
SKT200	75Ω BNC	23443-454
SKT201	75Ω BNC	23443-508
SKT300	75Ω BNC	23443-508
SKT301	75Ω BNC	23443-508
SKT600	4 way edge connector	23435-033
SKT601	4 way edge connector	23435-033
SKT602	4 way edge connector	23435-033
SKT603	4 way edge connector	23435-033
SKT604	4 way edge connector	23435-033
SKT605	4 way edge connector	23435-033
SKT606	75Ω BNC receptacle	23443-454
SKT607	Belling Lee miniature	23441-044
SKT608	Belling Lee miniature	23441-044
SKT609	75Ω BNC receptacle	23443-454
SKT700	75Ω BNC	23443-508
T1	Mains input 230V & 110V	43453-008
TR300	BC 239	28452-771
TR301	BC 109	28452-777
TR302	BC 109	28452-777
TR303	BC 109	28452-777
TR304	BC 108	28452-787
TR305	BC 109	28452-777
VT1	OC36	28425-867
VT100	ACY 17	28426-497
VT101	ACY 17	28426-497

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
VT400	BC109	28452-777
VT401	2N3702	28433-488
VT402	BC109	28452-777
VT403	BC109	28452-777
VT404	2N3702	28433-488
VT405	BC108	28452-787
VT406	BC108	28452-787
VT407	2N3702	28433-488
VT408	BC108	28452-787
VT409	BC108	28452-787
VT700	BC109	28452-777
Coarse atten. knob and skirt		41145-240
Fine atten. knob and skirt		41145-236

80 dB Attenuator - Fig. 7.12

C1	Cer 2.2pF ±0.5pF 750V	26324-042
C2	Cer 2.2pF ±0.5pF 750V	26324-042
C3	Cer 2.2pF ±0.5pF 750V	26324-042
L1	3 turn coil	35124-140
L2	5 turn coil	35124-407
L3	5 turn coil	35124-407
L4	5 turn coil	35124-407
L5	3 turn coil	35124-140
R1	Met film 91.67Ω ±0.2% ¼W	24633-161
R2	Met film 371.3Ω ±0.2% ¼W	24633-263
R3	Met film 45.83Ω ±0.2% ¼W	24633-063
R4	Met film 371.3Ω ±0.2% ¼W	24633-263
R5	Met film 91.67Ω ±0.2% ¼W	24633-161
R6	Met film 91.67Ω ±0.2% ¼W	24633-161
R7	Met film 371.3Ω ±0.2% ¼W	24633-263
R8	Met film 91.67Ω ±0.2% ¼W	24633-161
R9	Met film 144.4Ω ±0.2% ¼W	24633-212
R10	Met film 106.7Ω ±0.2% ¼W	24633-211
R11	Met film 144.4Ω ±0.2% ¼W	24633-212
R12	Met film 144.4Ω ±0.2% ¼W	24633-212
R13	Met film 106.7Ω ±0.2% ¼W	24633-211
R14	Met film 144.4Ω ±0.2% ¼W	24633-212
SA	Micro switch	23483-131
SB	Micro switch	23483-131
SC	Micro switch	23483-131
SD	Micro switch	23483-131
SE	Micro switch	23483-131
SF	Micro switch	23483-131
SG	Micro switch	23483-131
SH	Micro switch	23483-131
SKTA	75Ω BNC elbow	23443-458
SKTB	75Ω BNC	23443-453

11 dB Attenuator - Fig. 7.8 or 7.13

C1	Cer 3.3pF ±0.5pF	26324-048
C2	Cer 3.3pF ±0.5pF	26324-048
C3	Cer 3.3pF ±0.5pF	26324-048
L1	3 turn coil	35124-140
L2	5 turn coil	35124-407
L3	5 turn coil	35124-407
L4	5 turn coil	35124-407
L5	3 turn coil	35124-140
R1	Met film 438.6Ω ±½% ¼W	24634-703
R2	Met film 26.43Ω ±½% ¼W	24634-232
R3	Met film 219.3Ω ±½% ¼W	24634-611

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R4	Met film 26.43Ω ±½% ¼W	24634-232
R5	Met film 438.6Ω ±½% ¼W	24634-703
R6	Met film 654.1Ω ±½% ¼W	24634-807
R7	Met film 17.43Ω ±½% ¼W	24634-104
R8	Met film 654.1Ω ±½% ¼W	24634-807
R9	Met film 1.305kΩ ±½% ¼W	24635-012
R10	Met film 8.66Ω ±½% ¼W	24634-077
R11	Met film 1.305kΩ ±½% ¼W	24635-012
R12	Met film 438.6Ω ±½% ¼W	24634-703
R13	Met film 26.43Ω ±½% ¼W	24634-232
R14	Met film 438.6Ω ±½% ¼W	24634-703
SA	Micro switch	23483-131
SB	Micro switch	23483-131
SC	Micro switch	23483-131
SD	Micro switch	23483-131
SE	Micro switch	23483-131
SF	Micro switch	23483-131
SG	Micro switch	23483-131
SH	Micro switch	23483-131
SKTA	75Ω BNC elbow	23443-458
SKTB	75Ω BNC	23443-453

45 dB Attenuator - Fig. 7.7

C1	Cer 2.2pF ±0.5pF	26324-042
C2	Cer 2.2pF ±0.5pF	26324-042
C3	Cer 2.2pF ±0.5pF	26324-042
C4	Cer 2.2pF ±0.5pF	26324-042
L2	5 turn coil	35124-407
L3	5 turn coil	35124-407
L4	5 turn coil	35124-407
L5	3 turn coil	35124-140
R3	Met film 267.8Ω ±0.2% ¼W	24633-261
R4	Met film 45.58Ω ±0.2% ¼W	24633-062
R5	Met film 267.8Ω ±0.2% ¼W	24633-261
R6	Met film 91.67Ω ±0.2% ¼W	24633-161
R7	Met film 371.3Ω ±0.2% ¼W	24633-263
R8	Met film 91.67Ω ±0.2% ¼W	24633-161
R9	Met film 144.4Ω ±0.2% ¼W	24633-212
R10	Met film 106.7Ω ±0.2% ¼W	24633-211
R11	Met film 144.4Ω ±0.2% ¼W	24633-212
R12	Met film 144.4Ω ±0.2% ¼W	24633-212
R13	Met film 106.7Ω ±0.2% ¼W	24633-211
R14	Met film 144.4Ω ±0.2% ¼W	24633-212
SA	Micro switch	23483-131
SB	Micro switch	23483-131
SC	Micro switch	23483-131
SD	Micro switch	23483-131
SE	Micro switch	23483-131
SF	Micro switch	23483-131
SG	Micro switch	23483-131
SH	Micro switch	23483-131
SKTA	75Ω BNC elbow	23443-458
SKTB	75Ω BNC	23443-453

For symbols and abbreviations see introduction to this chapter

Chapter 7

Circuit diagrams

Circuit notes

1. COMPONENT VALUES

Resistors: No suffix = ohms. k = kilohms. M = megohms.
Capacitors: No suffix = microfarads. p = picofarads.
† value selected during test; nominal value shown.

2. VOLTAGES

These are d.c. and relative to chassis unless otherwise indicated. Measured with 20 kΩ/V meter.

3. SYMBOLS

arrow indicates clockwise rotation of knob.

etc., external front or rear panel marking.

tag on printed board.

other tag.

feed-through tag.

screwdriver adjustable preset.

signal path.

feedback path.

4. SWITCHES

Rotary switches are drawn schematically. Numbers or letters indicate control knob setting.

1F – 1st section (front panel), front
1B = 1st section, back
2F = 2nd section, front
etc.

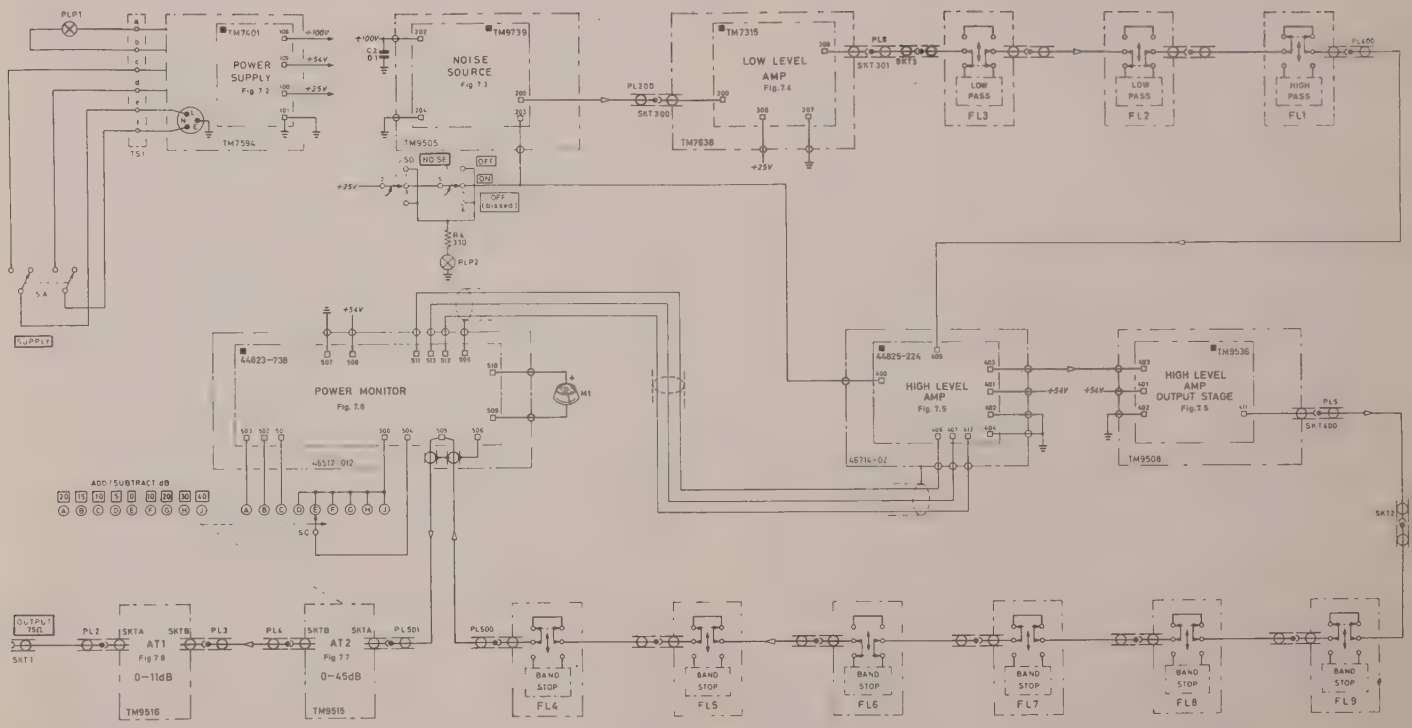


Fig. 7.1 Generator inter-unit wiring circuit

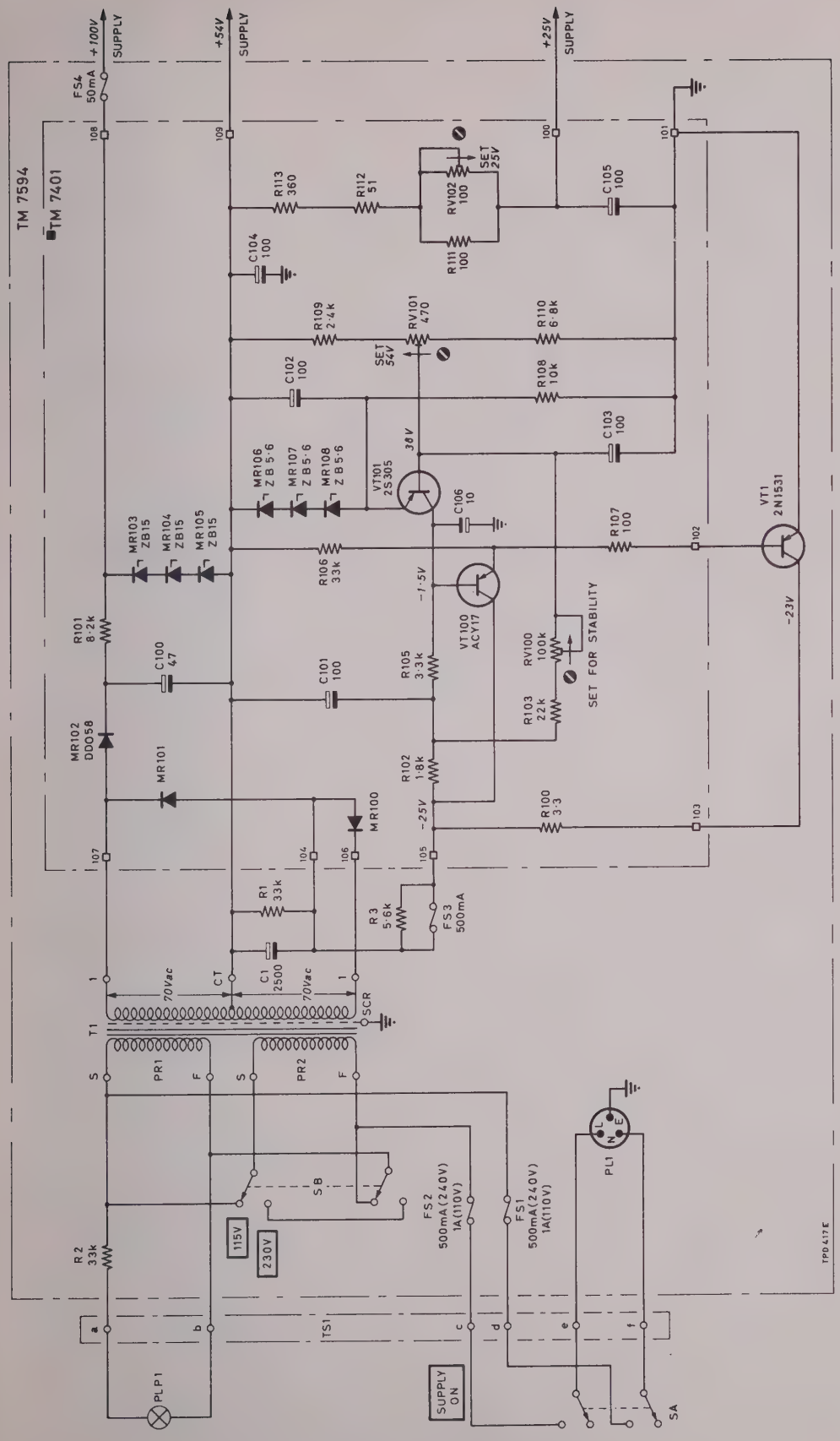


Fig. 7.2 Generator power supply circuit

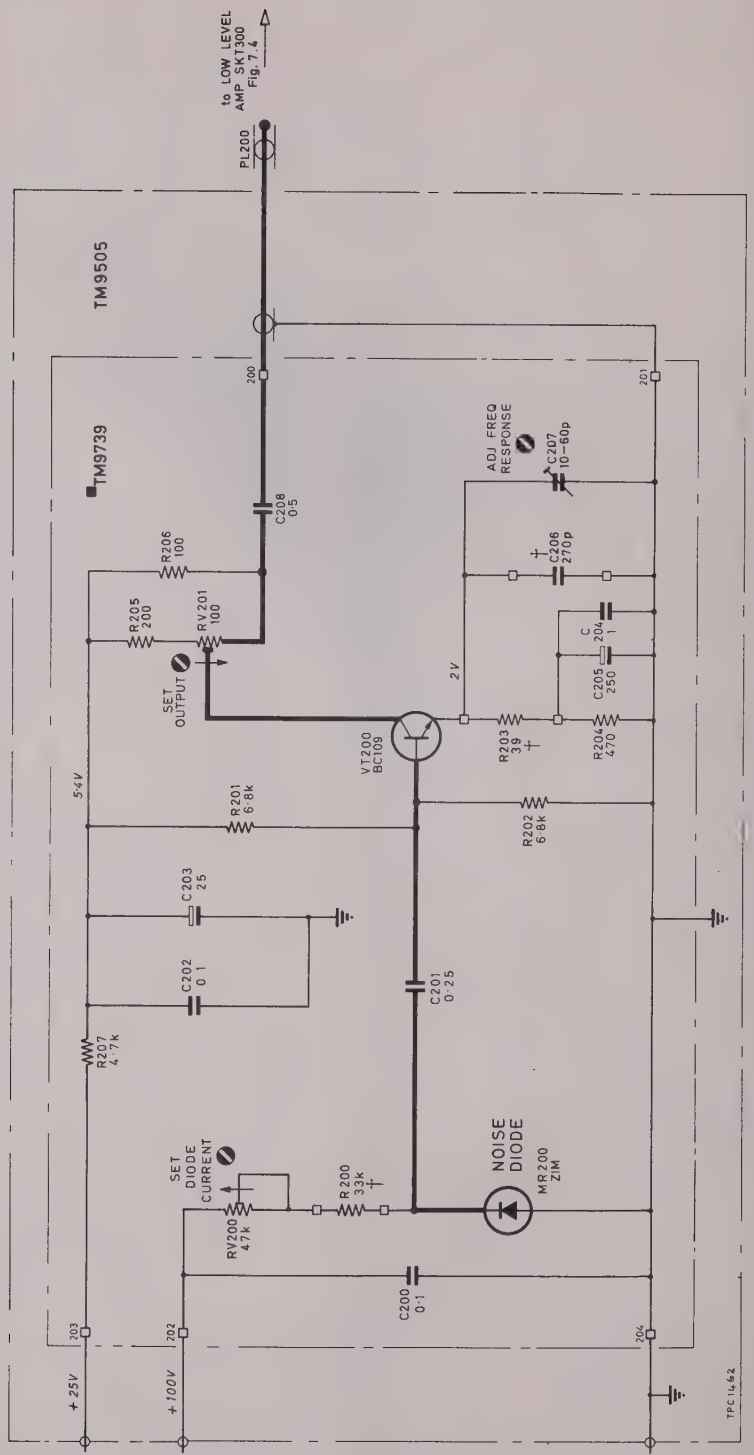


Fig. 7.3 Generator noise source circuit

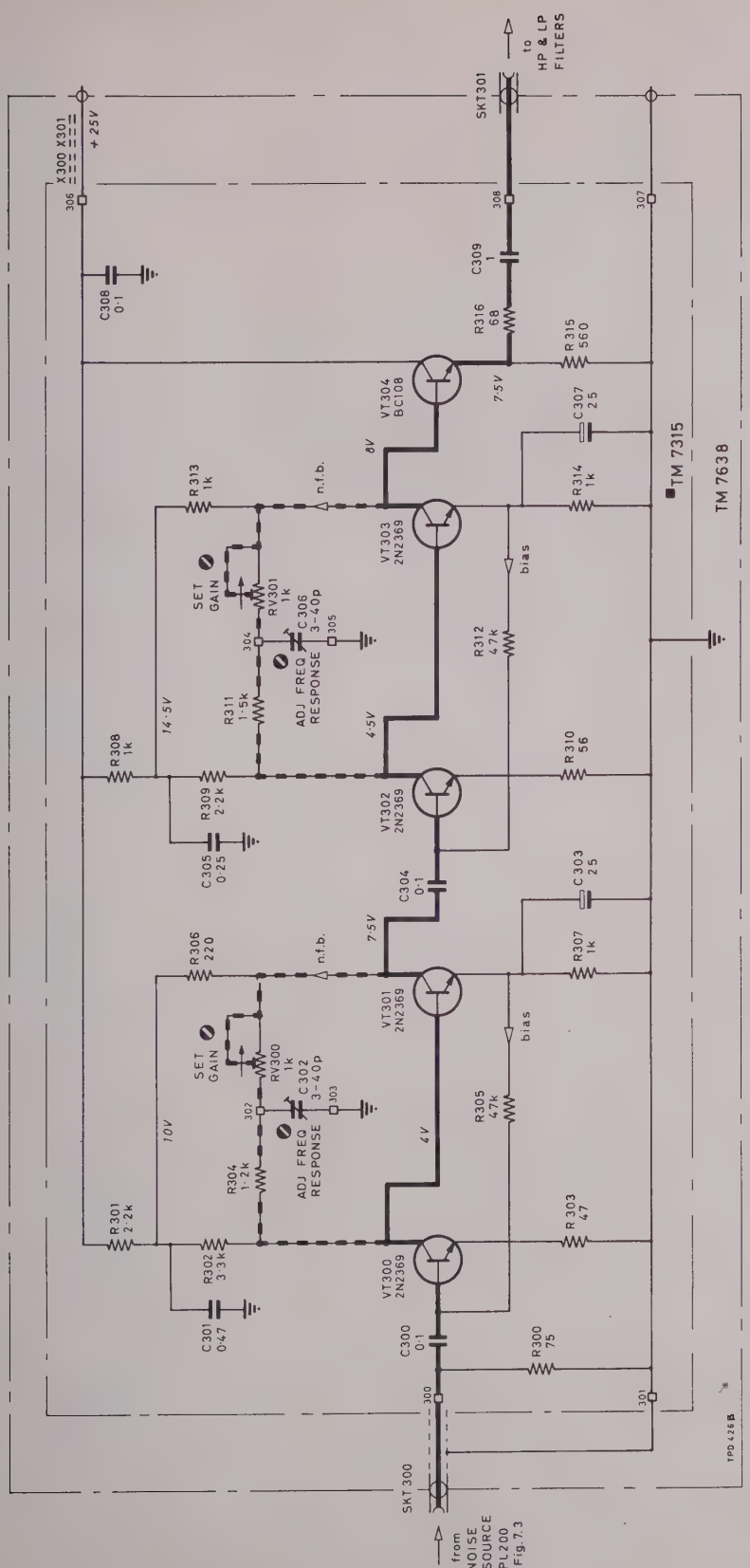


Fig. 7.4 Generator low level amplifier circuit

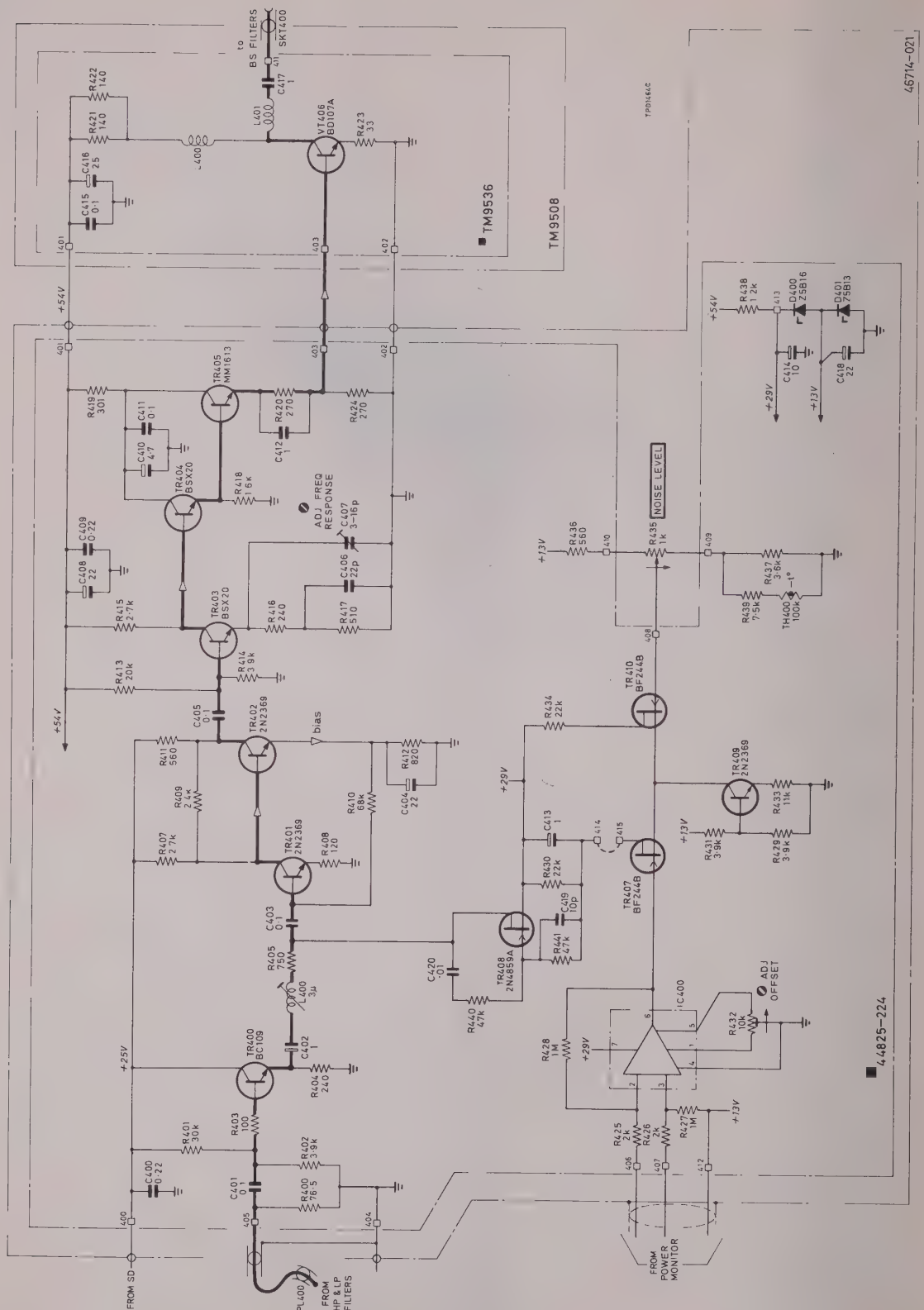


Fig. 7.5 Generator high level amplifier circuit

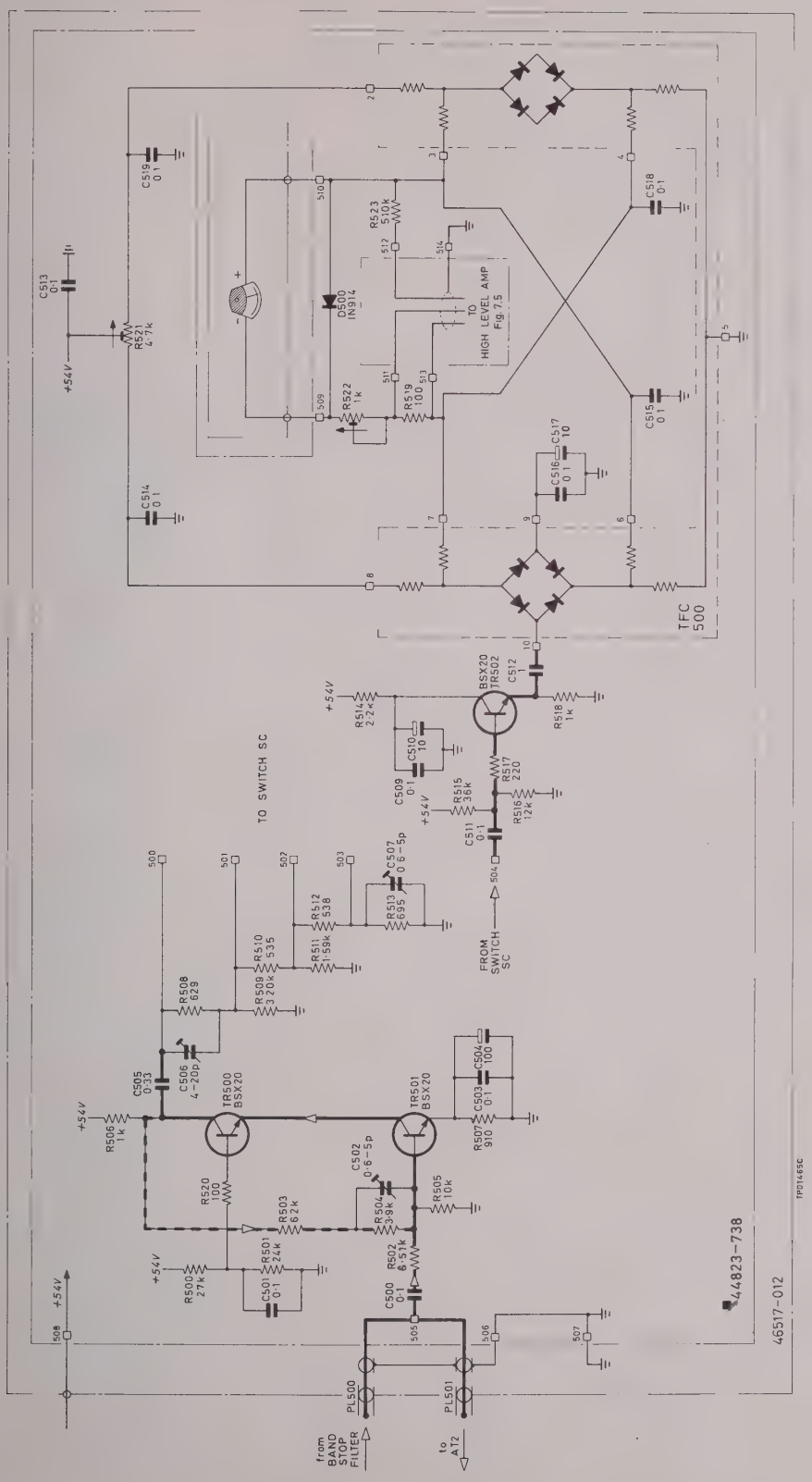
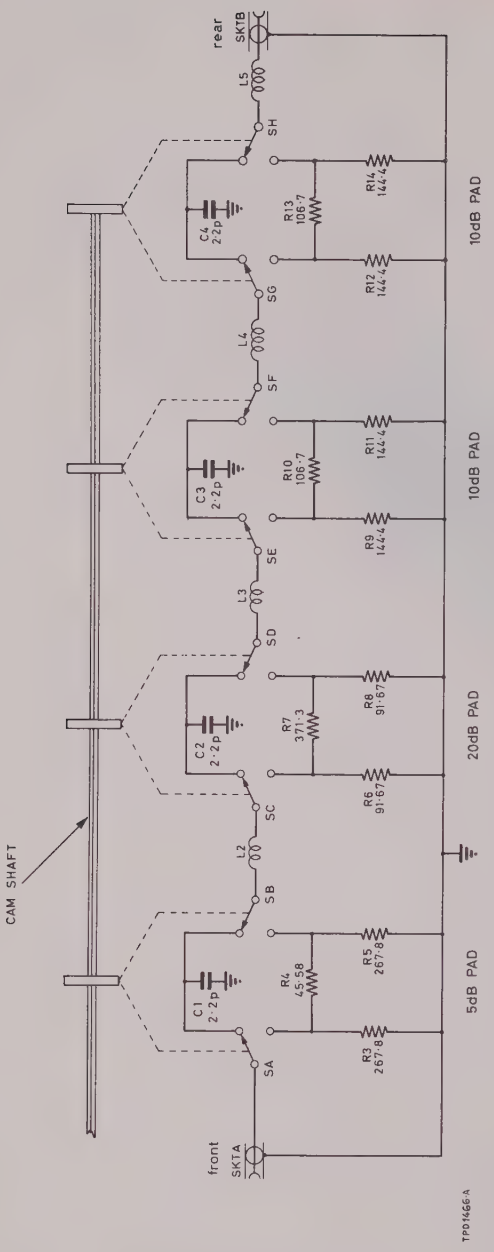


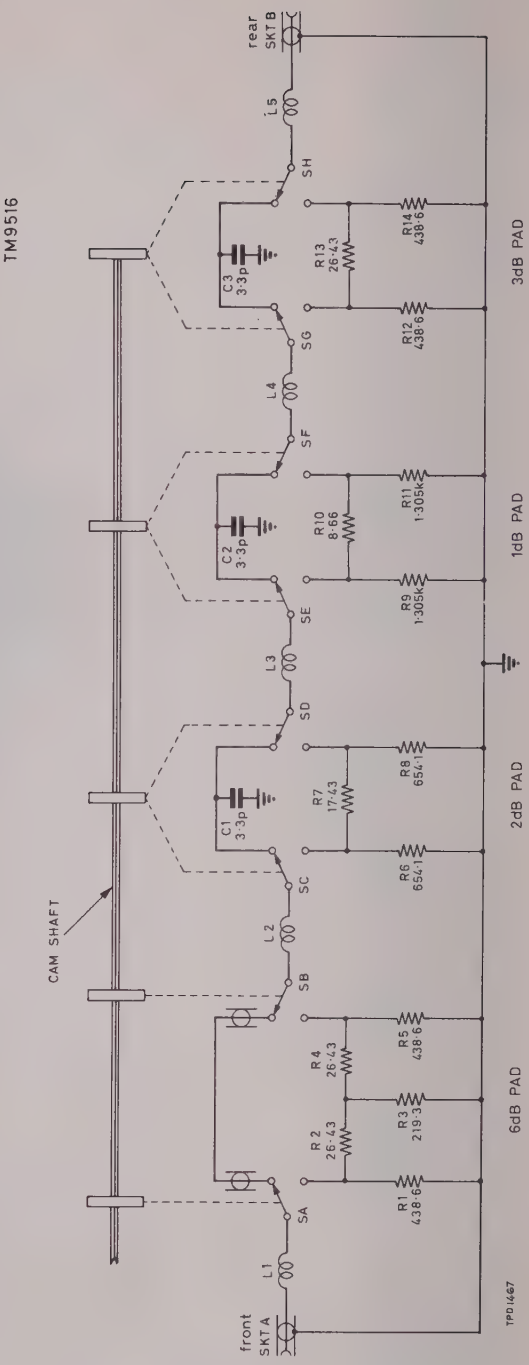
Fig. 7.6 Generator power monitor circuit



ADD/ SUBTRACT	ATTEN	PADS IN CIRCUITS (X)			
dB	dB	10dB	10dB	20dB	5dB
20	0				
15	0				X
10	0				X
5	0				X
0	5				X
10	15		X		X
20	25			X	X
30	35		X	X	X
40	45	X	X	X	X

RED LEGEND

Fig. 7.7 Generator 45 dB step attenuator circuit



SUBTRACT ATTEN	PADS IN CIRCUIT (X)				
dB	dB	1dB	2dB	3dB	6dB
0	0				
1	1	X			
2	2		X		
3	3	X	X		
4	4	X		X	
5	5		X	X	
6	6	X	X	X	
7	7	X			X
8	8		X		X
9	9	X	X		X
10	10	X		X	X
11	11		X	X	X

Fig. 7.8 Generator 11 dB step attenuator circuit

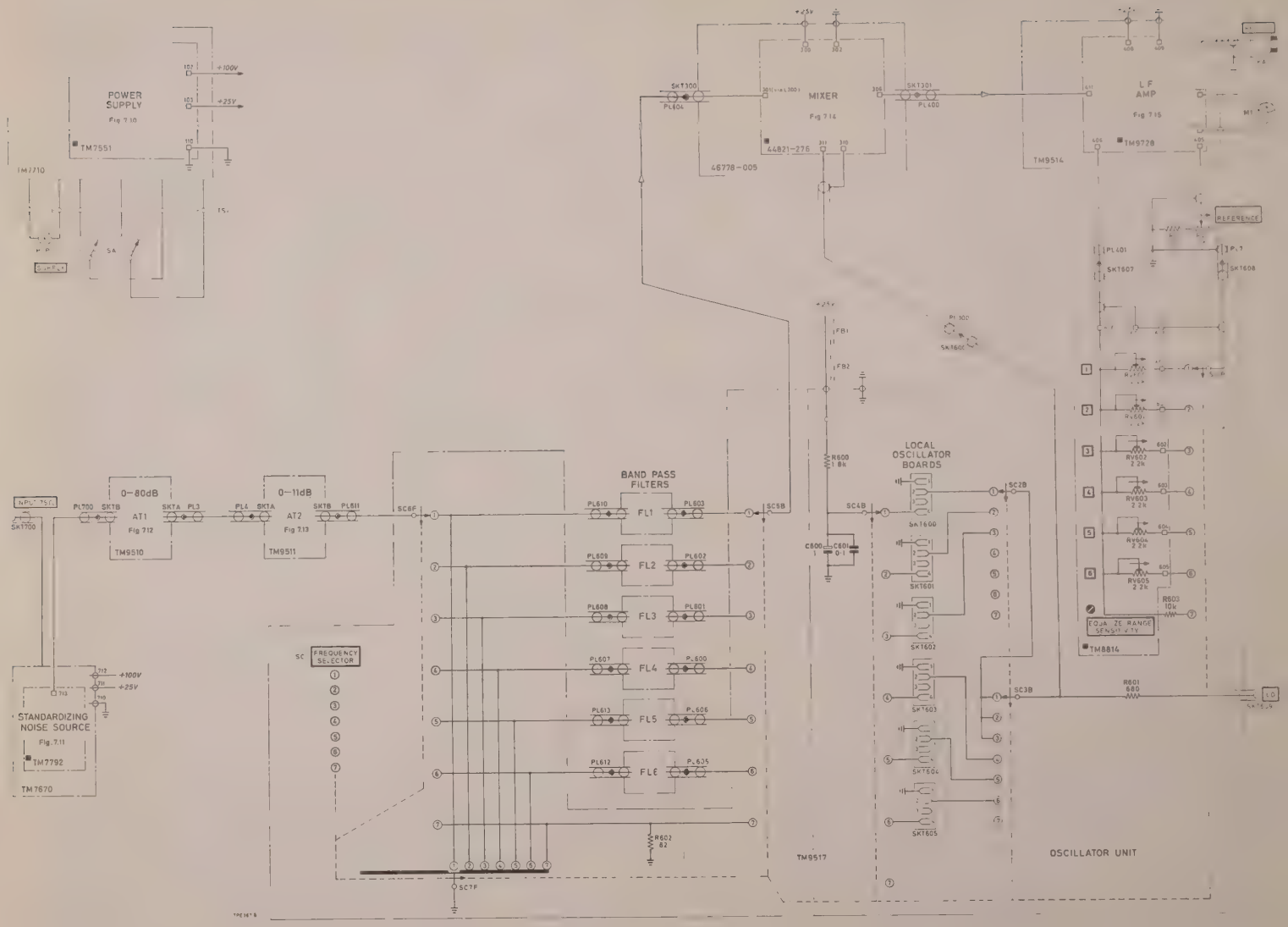


Fig. 7.9 Receiver inter-unit wiring circuit

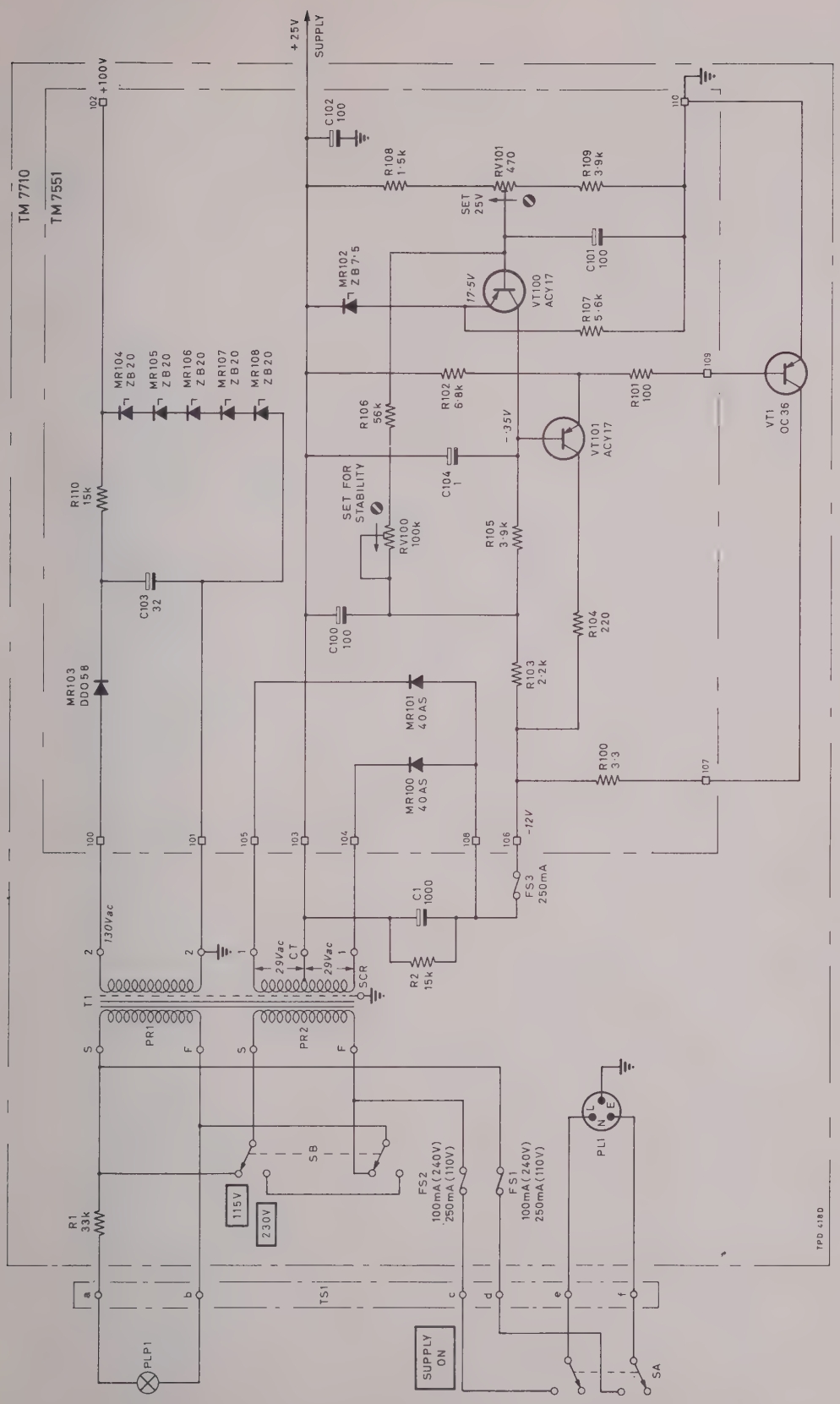


Fig. 7.10 Receiver power supply circuit

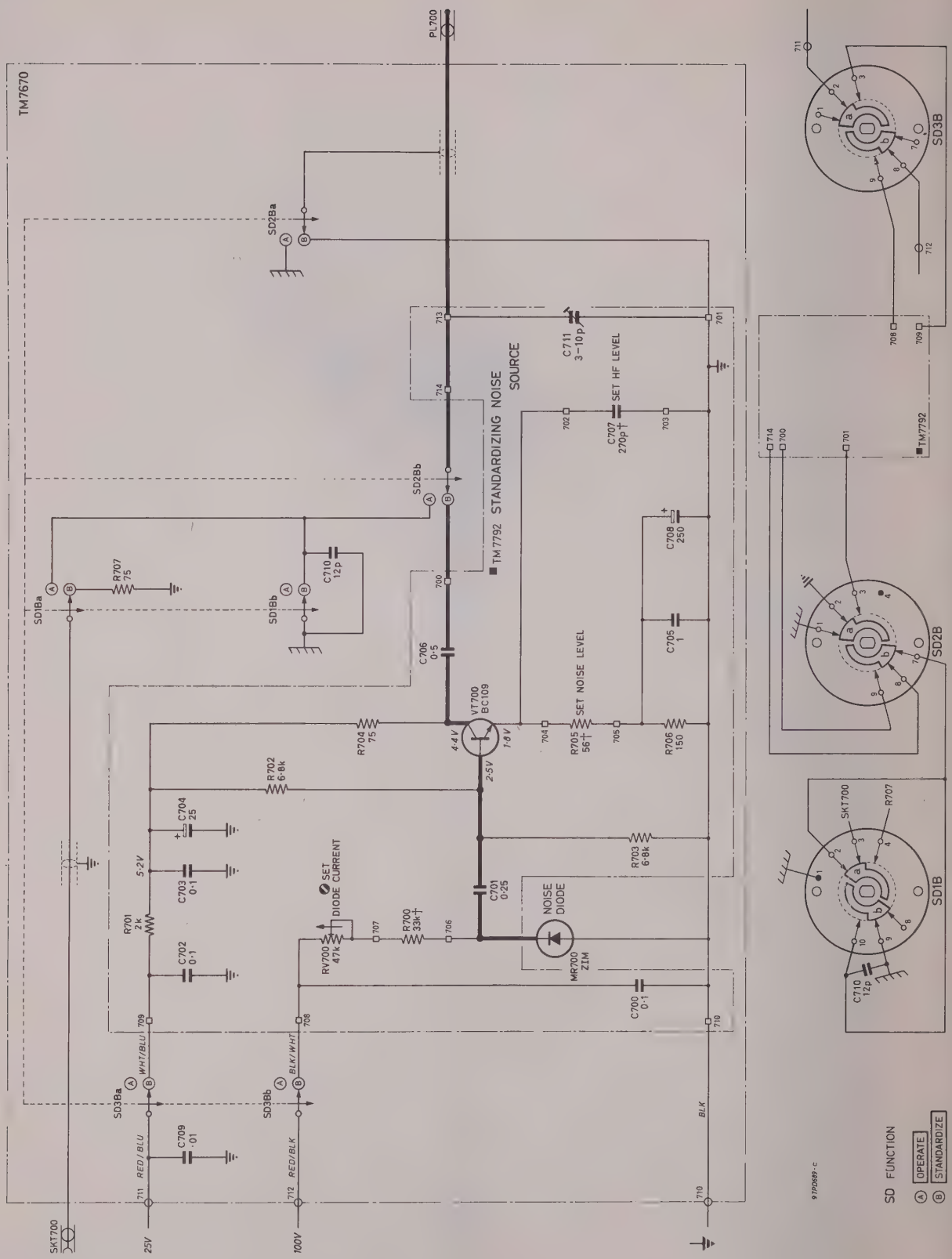
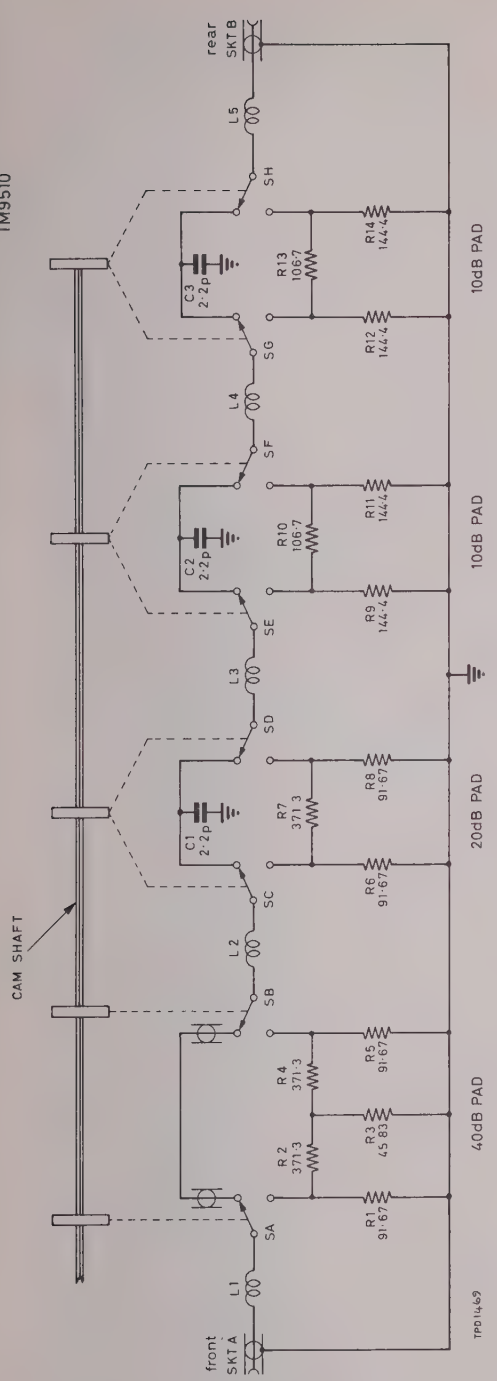
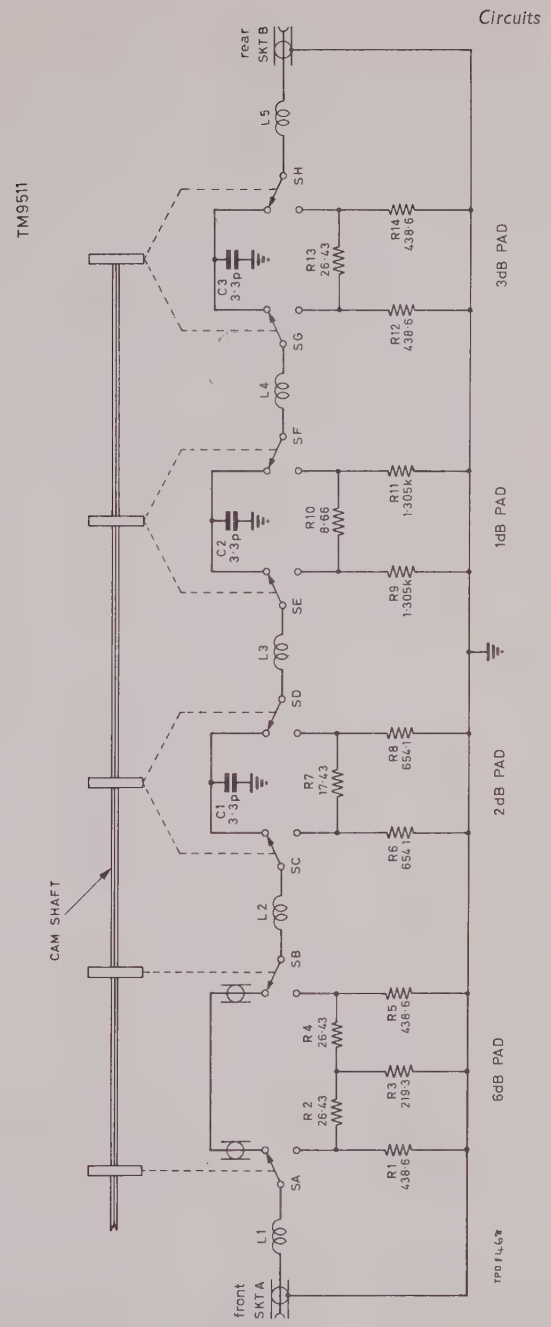


Fig. 7.11 Receiver noise source circuit



x pW	ATTEN dB	PADS IN CIRCUIT (X) 40dB	20dB	10dB (1)	10dB (2)
	0				
	10			X	
1	20		X		
10	30		X	X	
10^2	40	X			
10^3	50	X		X	
10^4	60	X	X		
10^5	70	X	X	X	
	80	X	X	X	X

Fig. 7.12 Receiver 80 dB step attenuator circuit



INDICATED N P R dB	x pW	ATTEN dB	PADS IN CIRCUIT (X) 1dB	2dB	3dB	6dB
0	13	11		X	X	X
1	10	10	X		X	X
2	7·9	9	X	X		X
3	6·3	8		X		X
4	5·0	7	X			X
5	4·0	6	X	X	X	
6	3·2	5		X	X	
7	2·5	4	X		X	
8	2·0	3	X	X		
9	1·6	2		X		
10	1·3	1	X			
11	1	0				

Fig. 7.13 Receiver 11 dB step attenuator circuit

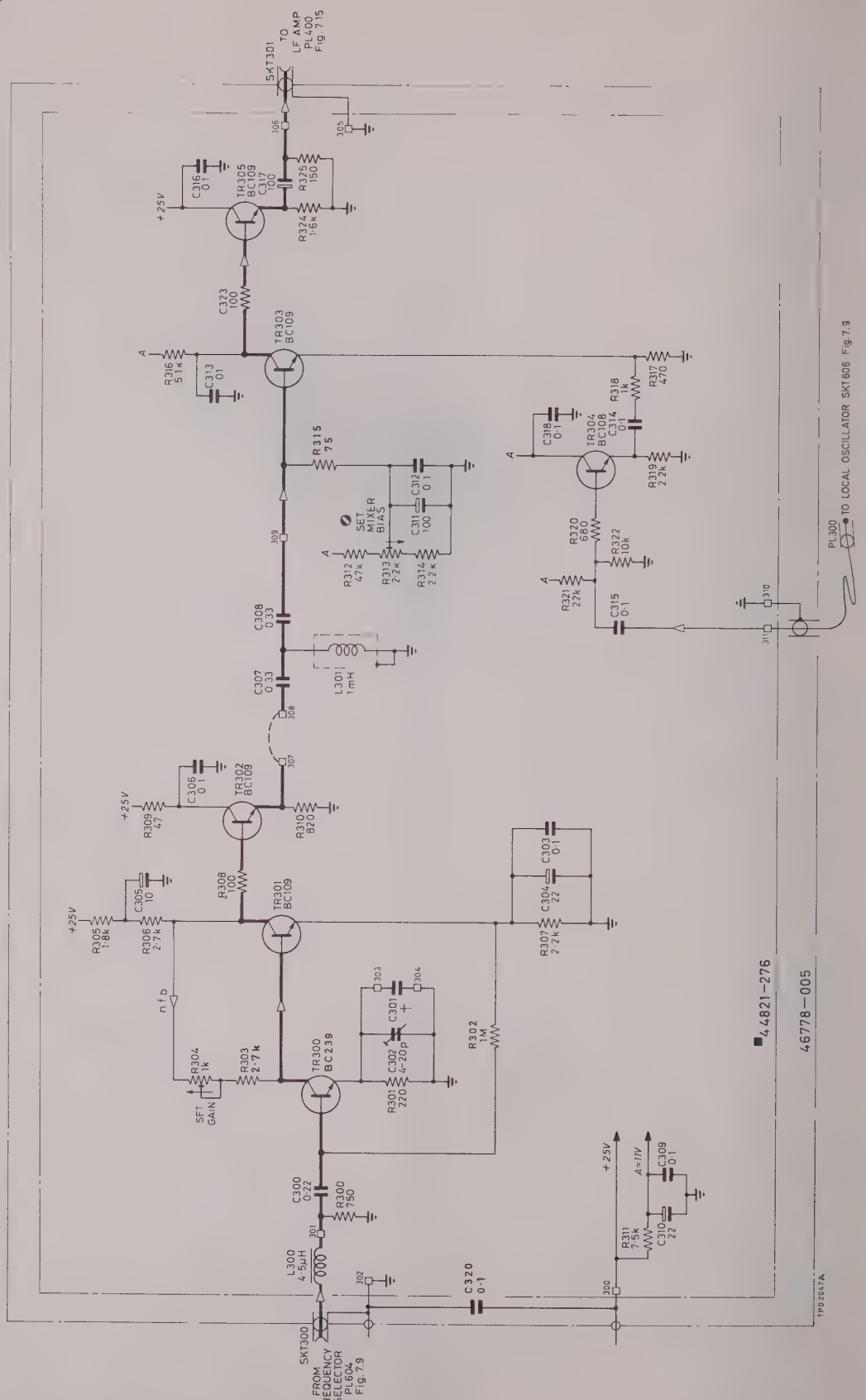


Fig. 7.14 Receiver mixer unit circuit

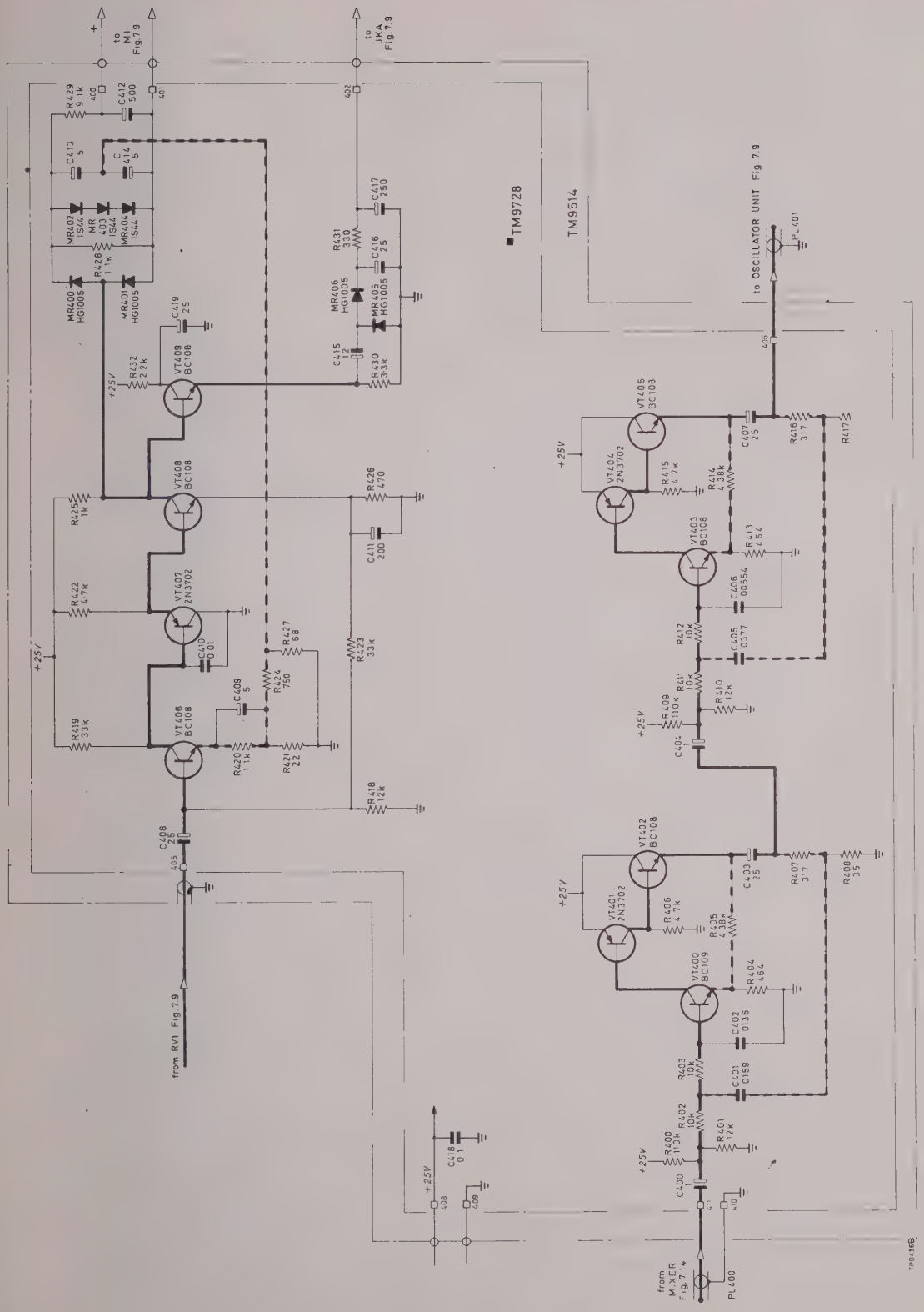


Fig. 7.16 Receiver l.f. amplifier circuit

FILTERS AND LOCAL OSCILLATORS

Filters which can be used with OA 2090B fall into two categories: 'B' version filters specially designed for OA 2090B and conforming with CCIR Recommendation 399-1 of the XIth Plenary 1966 Assembly; additionally the earlier 'A' version filters which can be used with OA 2090B when performance to CCIR Recommendation 399 of the Xth Plenary 1963 Assembly is adequate.

Selective filter units of the 'B' version should be ordered as a set. Band-limiting filters, or selective filter units without 'Filter set' numbers, must be ordered as individual items. Refer to the latest data sheet and price list for full ordering information.

'A' version filters *(CCIR Recommendation 399)*

Selective filter units

Frequency (kHz)	*Band-stop filter*	*Band-pass filter*	*Local oscillator*
14	TM 7729	TM 7730	TM 7793
27	TM 7729/21	TM 7730/21	TM 7793/4
34	TM 7729/12	TM 7730/12	TM 7793/2
40	TM 7729/1	TM 7730/1	TM 7793/1
56	TM 7729/13	TM 7730/13	TM 7793/3
70	TM 7729/2	TM 7730/2	TM 7794
105	TM 7729/3	TM 7730/3	TM 7794/1
185	TM 7729/4	TM 7730/4	TM 7794/2
245	TM 7729/22	TM 7730/22	TM 7794/9
270	TM 7729/5	TM 7730/5	TM 7794/3
342	TM 7729/16	TM 7730/16	TM 7794/6
534	TM 7729/6	TM 7730/6	TM 7794/4
1002	TM 7729/15	TM 7730/15	TM 7795/5
1248	TM 7729/7	TM 7730/7	TM 7795
2438	TM 7729/8	TM 7730/8	TM 7795/1
3886	TM 7729/9	TM 7730/9	TM 7795/2
5340	TM 7729/17	TM 7730/17	TM 7795/6
8002	TM 7729/10	TM 7730/10	TM 7795/3
12150	TM 7729/11	TM 7730/11	TM 7795/4

Band-limiting filters

Frequency (kHz)	*High-pass filter*	*Frequency (kHz)*	*Low-pass filter*
12	TM 7728	60	TM 7720/8
60	TM 7728/1	108	TM 7720
316	TM 7728/2	156	TM 7720/14
		204	TM 7720/10
		252	TM 7720/15
		300	TM 7720/1
		552	TM 7720/2
		1052	TM 7720/11
		1300	TM 7720/3
		2660	TM 7720/12
		4028	TM 7720/5
		4188	TM 7720/13
		5564	TM 7720/9
		8204	TM 7720/6
		12388	TM 7720/7

'B' version filters *(CCIR Recommendation 399–1)*

Selective filter units

Frequency (kHz)	*Filter set*	*Band-stop filter*	*Band-pass filter*	*Local oscillator*
16	TK 2094/9	54491-101	54492-101	54493-101
40	TK 2094/10	54491-111	54492-111	54493-111
56	TK 2094/11	54491-121	54492-121	54493-121
70	TK 2094	54491-011	54492-011	54493-011
98	TK 2094/12	54491-131	54492-131	54493-131
140	TK 2094/26	54491-271	54492-271	54493-271
185	TK 2094/14	54491-151	54492-151	54493-151
240	TK 2094/15	54491-161	54492-161	54493-161
270	TK 2094/1	54491-021	54492-021	54493-021
394	TK 2094/16	54491-171	54492-171	54493-171
534	TK 2094/2	54491-031	54492-031	54493-031
770	TK 2094/19	54491-201	54492-201	54493-201
1002	TK 2094/20	54491-211	54492-211	54493-211
1248	TK 2094/3	54491-041	54492-041	54493-041
1730	TK 2094/17	54491-181	54492-181	54493-181
2438	TK 2094/4	54491-051	54492-051	54493-051
3150	TK 2094/18	54491-191	54492-191	54493-191
3886	TK 2094/5	54491-061	54492-061	54493-061
4650	TK 2094/27	54491-281	54492-281	54493-281
5340	TK 2094/6	54491-071	54492-071	54493-071
7600	TK 2094/7	54491-081	54492-081	54493-081
11700	TK 2094/8	54491-091	54492-091	54493-091

Band-limiting filters

Frequency (kHz)	*High-pass filter*	*Low-pass filter*
12	TK 2096/2	
60	TK 2096	
316	TK 2096/1	
108		TK 2095/8
156		TK 2095/18
252		TK 2095/9
300		TK 2095
408		TK 2095/12
552		TK 2095/1
804		TK 2095/13
1052		TK 2095/14
1296		TK 2095/2
1796		TK 2095/10
2600		TK 2095/3
3284		TK 2095/11
4100		TK 2095/4
4892		TK 2095/19
5600		TK 2095/5
8160		TK 2095/6
12050		TK 2095/15
12360		TK 2095/7

Out-of-band filters

Frequency (kHz)	Filter set	Band-stop filter	Band-pass filter	Local oscillator
10	TK 2084	54494-011	54495-011	54496-011
50	TK 2084/1	54494-021	54495-021	54496-021
119	TK 2084/2	54494-031	54495-031	54496-031
270	TK 2084/3	54494-041	54495-041	54496-041
304	TK 2084/4	54494-051	54495-051	54496-051
331	TK 2084/5	54494-061	54495-061	54496-061
600	TK 2084/6	54494-071	54495-071	54496-071
607	TK 2084/7	54494-081	54495-081	54496-081
1499	TK 2084/8	54494-091	54495-091	54496-091
1549	TK 2084/9	54494-101	54495-101	54496-101
3200	TK 2084/10	54494-111	54495-111	54496-111
3250	TK 2084/11	54494-121	54495-121	54496-121
4715	TK 2084/12	54494-131	54495-131	54496-131
4765	TK 2084/13	54494-141	54495-141	54496-141
6199	TK 2084/14	54494-151	54495-151	54496-151
6300	TK 2084/15	54494-161	54495-161	54496-161
9023	TK 2084/16	54494-171	54495-171	54496-171
9073	TK 2084/17	54494-181	54495-181	54496-181
13627	TK 2084/18	54494-191	54495-191	54496-191

Corrections for 'B' version filters

For use with Sect. 2.6

Reduce the generator meter reading by the amount in dB shown in this table.

System capacity (channels)		24	60	60	96	120	132	192	252	300	432	600	612	792	900	960	972	1200	1260	1800	1872	2700
Baseband (kHz)		12-108	12-252	60-300	12-108	60-552	12-552	12-804	12-1052	60-1296	12-1796	60-2600	12-2600	12-3284	316-4100	60-4100	12-4100	316-5600	60-5600	316-8160	12-8160	316-12360
Band stop filter																						
Part of Set TK	Frequency (kHz)																					
2094/9	16	0.40	0.15	-	0.10	-	0.05	0.05	0.05	-	0	-	0	0	-	-	0	-	-	-	-	-
2094/10	40	0.30	0.10	-	0.05	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2094/11	56	0.30	0.10	-	0.05	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2094	70	-	0.45	0.40	0.25	0.20	0.20	0.15	0.10	0.10	0.05	0.05	0.05	0.05	-	0.05	0.05	-	0	-	0	-
2094/12	98	0.30	0.15	0.15	0.10	0.05	0.05	0.05	0.05	0	-	-	-	-	-	-	-	-	-	-	-	-
2094/14	185	-	0.15	0.15	0.10	0.05	0.05	0.05	0.05	0.05	0	0	0	-	-	-	-	-	-	-	-	-
2094/15	240	-	0.15	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0	0	0	-	-	-	-	-	-	-	-	-
2094/1	270	-	-	0.25	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0	0	0	-	0	0	-	0	-	-	-
2094/16	394	-	-	-	0.15	0.15	0.15	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2094/2	534	-	-	-	-	0.25	0.25	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0
2094/19	770	-	-	-	-	-	-	0.20	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0	0	-	-	-
2094/20	1002	-	-	-	-	-	-	-	0.20	0.20	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
2094/3	1248	-	-	-	-	-	-	-	-	0.20	0.15	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0	0
2094/17	1730	-	-	-	-	-	-	-	-	-	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.05	0.05	-	-	-
2094/4	2438	-	-	-	-	-	-	-	-	-	-	0.20	0.20	0.15	0.15	0.15	0.15	0.10	0.10	0.05	0.05	0.05
2094/18	3150	-	-	-	-	-	-	-	-	-	-	-	-	0.30	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.05

At 3886 kHz and above the insertion loss is negligible and no correction is required.

Corrections for 'A' version filters

For use with Sect. 2.6

Reduce the generator meter reading by the amount in dB shown in this table.

System capacity (channels)		12	24	36	48	60	60	120	132	240	300	600	900	960	1200	1260	1800	2700
Baseband (kHz)		12–60	12–108	12–156	12–204	12–252	60–300	60–552	12–552	60–1052	60–1300	60–2660	316–4188	60–4028	316–5564	60–5564	316–8204	316–12388
Band stop filter																		
Part of	*Frequency (kHz)*																	
TM 7729	14	0.6	0.3	0.2	0.2	0.1	–	–	0	–	–	–	–	–	–	–	–	–
TM 7729/21	27	1.0	0.5	0.3	0.3	0.2	–	–	0.1	–	–	–	–	–	–	–	–	–
TM 7729/12	34	0.9	0.5	0.3	0.2	0.2	–	–	0.1	–	–	–	–	–	–	–	–	–
TM 7729/1	40	1.0	0.5	0.4	0.3	0.2	–	–	0.1	–	–	–	–	–	–	–	–	–
TM 7729/13	56	1.0	0.6	0.5	0.3	0.3	–	–	0.1	–	–	–	–	–	–	–	–	–
TM 7729/2	70	–	0.8	0.5	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0	–	0	–	0	–	–
TM 7729/3	105	–	0.6	0.7	0.5	0.4	0.4	0.2	0.2	0.1	0.1	0	–	0	–	0	–	–
TM 7729/4	185	–	–	–	0.6	0.4	0.4	0.2	0.2	0.1	0.1	0	–	0	–	0	–	–
TM 7729/22	245	–	–	–	–	0.4	0.5	0.2	0.2	0.1	0.1	0	–	0	–	0	–	–
TM 7729/5	270	–	–	–	–	–	0.5	0.3	0.2	0.1	0.1	0	–	0	–	0	–	–
TM 7729/6	534	–	–	–	–	–	–	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0	0	0	0
TM 7729/15	1002	–	–	–	–	–	–	–	–	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0	0
TM 7729/7	1248	–	–	–	–	–	–	–	–	–	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0
TM 7729/8	2438	–	–	–	–	–	–	–	–	–	–	0.3	0.2	0.2	0.1	0.1	0.1	0.1
TM 7729/9	3886	–	–	–	–	–	–	–	–	–	–	–	0.3	0.3	0.2	0.2	0.2	0.1
TM 7729/17	5340	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3	0.3	0.2	0.1
TM 7729/10	8002	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3	0.2
TM 7729/11	12150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.3

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